BELL TELEPHONE QUARTERLY

VOL. XIII JANUARY, 1934

EXHIBITING TELEPHONE PROGRESS AT THE WORLD'S FAIR

SYSTEMS OF LONG TELEPHONE LINES

THE ROLE OF DROP WIRE

COMMUNICATION WITH ELECTRICAL BRAINS

A CENSUS PORTRAYAL OF THE AMERICAN FAMILY

AMERICAN TELEPHONE & TELEGRAPH CO. • NEW YORK

BELL TELEPHONE QUARTERLY

A Medium of Suggestion and a Record of Progress

CONTENTS FOR JANUARY 1934

PAGE

Exhibiting Telephone Progress at the World's Fair—*C. T. Smith* . . . 3

Systems of Long Telephone Lines—*J. J. Pilliod* 23

The Rôle of Drop Wire—*R. A. Haislip* 36

Communication with Electrical Brains—*John Mills* 47

A Census Portrayal of the American Family—*R. L. Tomblen* 58

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SECTION OF TELEPHONE LINE IN WESTERN MONTANA

THIS IS PART OF A LINE FROM MINNEAPOLIS TO SEATTLE, WHICH IS ONE LINK IN THE SYSTEM OF LONG TELEPHONE ROUTES IN THE UNITED STATES DESCRIBED IN THE ARTICLE "SYSTEMS OF LONG TELEPHONE LINES" IN THIS ISSUE.

Exhibiting Telephone Progress at the World's Fair

THROUGHOUT the entire period of the World's Fair, the telephone exhibit proved to be one of the most popular and most talked of features at A Century of Progress Exposition in Chicago. Judging from the large crowds which the exhibit attracted, the animated interest which the visitors displayed, and the widespread favorable comment which the demonstrations stimulated, there can be little doubt that the telephone exhibit was a highly successful public relations undertaking, both for the Bell System and for the telephone industry as a whole. Millions of people throughout the country have a better understanding of the telephone service which they take so much as a matter of course, and a new realization of the important part which the human element plays in rendering that service.

The broad concept underlying the Chicago Exposition is signified in the name: A Century of Progress. The past one hundred years have witnessed tremendous advancement in man's knowledge of the forces of nature, and the application of that knowledge in industry has resulted in profound changes in the everyday life of millions of individuals. It was this story of scientific discovery which was unfolded to the millions of World's Fair visitors in simple and living terms designed to give the individual without technical background or engineering training a better understanding of the scientific forces which, in large measure, have shaped the course of his daily life. One of the most vital chapters in this story of scientific achievement is the development of the art of telephone communication. Certainly in no other field of scientific endeavor

has progress been more rapid; in few have the social consequences been more far-reaching.

The purpose of the telephone exhibit was to give the public a fuller knowledge of telephone service and of the operations and equipment involved in providing that service, and to impress upon the visitor something of the institutional character of the Bell System. These objectives and the "progress" concept of the Exposition, together with the consideration that the demonstrations should be of general public interest, were fundamental in the selection of material for presentation at the World's Fair. Accordingly, there were included on the second floor of Communications Hall, which was devoted entirely to Bell exhibits, demonstrations of long distance service, the dial telephone, "scrambled speech," multi-channel telegraphy, four typical switchboard operations, and one of the latest developments of transmission research whereby sound is reproduced in full auditory perspective. Plans for these exhibits had been laid sufficiently far in advance of the Fair to permit the development of special apparatus and equipment by Bell Telephone Laboratory experts, and the construction of an especially designed building which provided ample space and made possible an exhibition hall possessing a unity and a dignity which were most impressive. Moreover, every exhibit was a unit in itself and so placed with reference to aisle space as to receive maximum attention from the attending throngs. Areas devoted to the demonstration of local and long distance commercial services were located directly below on the first floor, and institutional displays and the executive headquarters of the exhibit were to be found in two of the towers outside, forming a part of Communications Court.

As readers of the BELL TELEPHONE QUARTERLY know from a previous article,[1] the general arrangements for the Bell System exhibit were under the guidance of Vice-presidents F. B. Jewett

[1] "The Bell System Exhibit at the Century of Progress Exposition," by John Mills; BELL TELEPHONE QUARTERLY, January 1933.

and A. W. Page of the American Telephone and Telegraph Company. From the inception of the general idea, however, Mr. John Mills of the Bell Telephone Laboratories' staff was in charge of all architectural and technical details, assisted by Mr. M. B. Long, also of the Laboratories' staff. The history of the exhibit, in fact, is in two long and interesting divisions—the arduous and exacting period of preparation which extended over two years and the period of operation and demonstration.

The Bell System demonstrations were not in any sense designed to be museum pieces or automatic displays of telephone service, but were intended to stress the common factor in all telephone service and the moving spirit behind all progress in the communications art—the human element in the business. This tremendously potent factor was recognized and provided for at the Bell System exhibit. All the demonstrations, in so far as possible, were personalized and, furthermore, were designed for active public participation. As evidence that this personalized method of demonstrating created a real impression on the public are the hundreds of enthusiastic letters which were received during the course of the summer and the thousands of favorable comments made at the exhibit itself.

Attesting to the popularity and appeal of the telephone exhibit at A Century of Progress Exposition is the fact that, from the opening of the Fair on May 27 until its close on November 12, attendance at the exhibit totaled 6,350,000 persons. Making allowances for "repeaters" on the basis of sampling studies, at least 5,000,000 different individuals came to the Bell System exhibit and caught something of the message which that exhibit conveyed. These visitors came from every State in the Union and represented all ages and every social and economic level. On the average, about one out of every four persons entering the Fair grounds each day visited the exhibit, and at least three out of four saw the telephone demonstration on one of the days they visited the Exposition.

Communications Hall, which was a part of the Electrical Group of buildings, was located at about the center of the island directly across from the Hall of Science. It connected with the mainland through the Hall of Social Science over the 16th Street bridge and with the Federal and States groups of buildings over a viaduct. Facing the lagoon on one side and Lake Michigan on the other, the Hall was one of the most ideally located buildings on the Exposition grounds and caught the main flow of traffic on the island. There were some eight main entrances to the telephone exhibit space, and two inside stairways connecting the first and second floor areas. The northern entrance on the second floor, however, proved to be by far the most popular; about half of the total attendance reached the exhibit through that portal.

On entering the second floor of the telephone exhibit, one of the first things which attracted the attention of the visitor was a large crowd around the balcony rail, some seated listening with earphones to the performance on a sound proof stage across the way and others standing behind the seats waiting their turn at the receivers. This performance was the demonstration of Acoustical Illusions, or the "Oscar Show" as it was popularly called, because of Oscar, the "Dummy with Microphone Ears," who played an important part in the performance. About 4,500,000 persons stopped to observe the show and close to 600,000 actually heard the demonstration. With space available for only 30 sets of receivers, it was physically impossible to accommodate all who desired to listen.

Since this was the first time that this demonstration had been publicly presented in the form used at the Fair, considerable experimentation was necessary to develop the most effective technique of presentation. As finally worked out, a large part of the show was put on with the stage curtains closed; the remarks of the demonstrators were addressed to "Oscar" rather than to the listeners as an audience. The show itself usually lasted for a period of six or seven minutes,

FIGURE 1. A GENERAL VIEW OF THE ELECTRICAL GROUP OF EXHIBITION BUILDINGS, SHOWING THE FOUR TOWERS SURROUNDING COMMUNICATIONS COURT.

FIGURE 2. A GENERAL VIEW OF A PORTION OF THE SECOND FLOOR AREA OF THE TELEPHONE EXHIBIT FROM THE NORTHERN ENTRANCE.

FIGURE 3. THE STAGE OF THE "OSCAR" DEMONSTRATION.

FIGURE 4. LISTENING TO THE "OSCAR" DEMONSTRATION.

with an interval of about a minute between performances. It started with the opening of the curtains on the sound proof stage for the purpose of attracting the attention of the listeners. At this point they were told to be sure to keep a receiver to each ear; that if they shared earphones they would find themselves, in effect, deaf in one ear.

Following these preliminary instructions, the curtains were closed and most of the illusions were put on with the demonstrator out of sight of his audience. A voice would say, "Well, I guess I'll go down and put some coal on the fire," or "It's time to go up on the roof and feed the pigeons." Immediately after, the sound of a closing door could be heard; apparently the demonstrator had left the stage. For a moment it would be silent, and then a voice whispered directly into the left ear of the listener, "I beg your pardon, did you drop this?"; and then perhaps in the right ear, "Would you move over, please. I can't see a thing." Many of the listeners on hearing a voice, apparently of someone standing behind them, would look around to see who was speaking. Later, a loud "Boo" brought instantaneous reactions on the part of the listeners in the form of startled exclamations and much laughter. The actions and amused expressions on the faces of the listeners throughout the performance testified to their enjoyment and to the reality of the illusions which were being conveyed. All of their spontaneous movements in response to what they heard mystified and provided much entertainment for the spectators without earphones, standing behind the seats.

At the end of this part of the performance the curtains were again opened and a brief explanation of the demonstration was given, which went something along this line: "This show, ladies and gentlemen, is a demonstration of one of the developments of the research laboratories of the Telephone Company which are constantly striving to improve the quality of telephone transmission. You noticed that all the sounds made here on the stage—from the highest to the lowest note and

from the faintest whisper to the loudest noise—were faithfully reproduced in the receivers you are using. You noticed also that you could actually locate the direction from which these sounds came. The secret of the show is my silent partner here, Oscar, the Dummy. Oscar has a microphone in his left ear which is connected directly to the receiver which you hold to your left ear; in his right ear is another microphone which connects to the receiver at your right ear. Thus, when I am at Oscar's right the microphone on that side picks up the sounds and conveys them to you just as Oscar hears them. When I am at Oscar's left, the microphone in his left ear picks up the sounds and you hear them just as he does."

The demonstration of long distance telephony was one of the most popular features of the telephone exhibit. It was designed to demonstrate the speed with which long distance calls are completed, the operations involved in establishing connections, the high quality of transmission, and the national range of the service. Visitors were offered the opportunity of participating in this demonstration by making personal calls over the regular long distance lines. This feature of the telephone exhibit became very widely known during the course of the summer and the one question which the Bell exhibit attendants were called upon to answer more frequently than any other was, "Will you please tell me where to make a free Long Distance call?" Almost invariably the World's Fair guides, in conducting parties through the exhibit, would call attention to the large map of the United States which was visible from all parts of the second floor area and explain that souvenir long distance calls could be made to any one of 55 cities in the country. Many of the conductors on the transportation buses in the Grounds, in announcing the Communications Hall stop, would say, "This is the place where you make your free long distance telephone calls." The demand for the cards entitling the visitors to make these calls

became so great that it created one of the first operating problems at the exhibit.

One of the procedures tried for distributing the cards was a system of drawings by lot. Persons desirous of making calls were given numbered tickets and drawings were held every hour. Although this method seemed to be accepted in great good humor, by persons not fortunate enough to receive the opportunity of making a call as well as those who were, it was felt to be somewhat unfair to individuals who were really anxious to participate in the long distance demonstration and willing to wait their turn to do so. It was decided, therefore, to discontinue the drawings and to have the applicants wait in line for the tickets, a procedure with which they were all familiar and ready to accept as being entirely fair. In order to make the wait for the tickets as comfortable as possible, chairs were provided in the Hall of the Electrical Echo, opening on Communications Court. Tickets were given out in the order of seating, one ticket approximately every four minutes. At few times during the Fair were there less than 30 persons waiting to apply for the souvenir calls; and on days when the attendance was especially large, as many as 50 or 60 individuals would be found waiting outside of the Echo Tower before the doors had opened in the morning. To many people the wait in the Tower was a welcome rest from the arduous business of "seeing the Fair."

As soon as a visitor had received a ticket, he was directed to the long distance demonstration on the second floor of the exhibit, where the calls were actually made. Here, he was escorted to one of the two booths at either end of the demonstration area, where he placed his call in the usual way. Outside, on a very large map of the United States, the route of the call was displayed by means of a band of light. Immediately below the map a crowd was always to be found listening in on the conversations. Originally 18 receivers were provided for this purpose, but so many people were anxious to

hear the conversations that 40 additional earphones were installed; there were few times during the Fair that most of them were not in use. Apparently, the presence of the listeners did not greatly disturb the person doing the calling. As soon as the telephone had been answered at the distant point, the operator announced that the call was from the telephone exhibit at the World's Fair and that other people would be listening. Frequently, the person making the call would reinforce this statement by saying good-naturedly, "About 50 people are listening outside here, so don't bring any of the family skeletons out of the closet."

Probably at no other place on the Fair Grounds was there an exhibit more crammed with the drama, the pathos, and the humor of everyday life than at this demonstration of long distance telephone service. Members of families who had not seen or heard each other for years were reunited in the brief space of a minute. Very frequently in the conversations, emergency requests were made for money, and such comments and questions as "Why don't you write?," "We'll be home on Tuesday," "We saw so-and-so and he asked to be remembered to you." "Father and Mother are well," and even "The baby has a new tooth," ran through the conversations. One young man calling a friend in Dallas, Texas, learned over the telephone that she had been killed in an automobile accident. The reactions of the listeners to all of this were instantaneous and unaffected. A hushed silence would pervade the air of the exhibit at one moment—and at the next, amused smiles and bursts of laughter. So natural and human were the conversations that many a telephone Romeo received a good-natured kidding from the crowd as he left the booth after having completed his call.

Some 25,000 persons actually participated in the demonstration by making calls. For many of these it was their first experience with the long distance telephone. Probably double that number took part in the conversations at the points called

FIGURE 5. IN THE HALL OF THE ELECTRICAL ECHO, WAITING THEIR TURN TO CALL LONG DISTANCE.

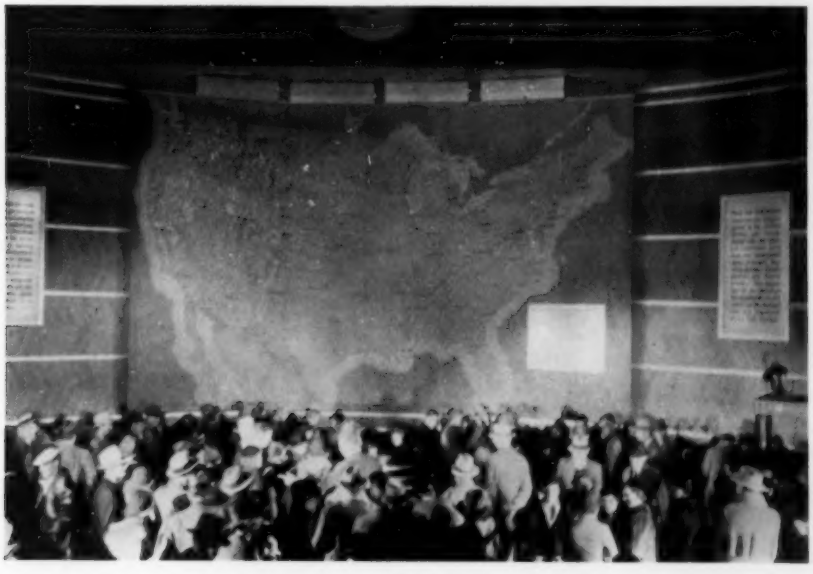


FIGURE 6. A CROWD AT THE LONG DISTANCE DEMONSTRATION.

FIGURE 7. FINDING OUT HOW THE DIAL TELEPHONE WORKS.

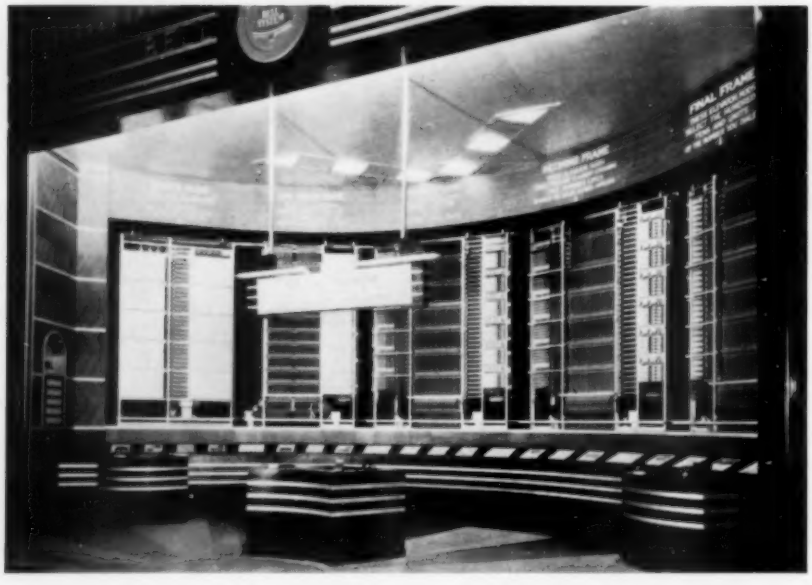


FIGURE 8. A GENERAL VIEW OF THE EQUIPMENT IN THE DIAL TELEPHONE EXHIBIT.

Almost a million persons listened in at the exhibit. These individuals must have been impressed, unconsciously at least, by the part which the telephone plays in their everyday life. Many of the participants in the demonstration, after having completed their call, took the trouble to search out an attendant and say, in effect, "I don't know whom to thank for the call I just made, but I want you to know that it was one of the most wonderful experiences I've had at the Fair." Numerous letters of appreciation from persons who had made souvenir calls were received throughout the summer. Foremost among the comments at the demonstration itself were those expressing surprise that long distance connections could be completed so rapidly and with so little trouble over great distances. Indeed, one rather skeptical lady appeared at the Hall of the Electrical Echo early one morning and said that she had heard that now it was actually possible to talk as far as Los Angeles over the telephone. Even when assured by the attendant that this was an everyday occurrence, she shook her head rather dubiously and said that she was going to wait in line for one of the tickets just to find out if it were really so.

A third very popular spot in the telephone exhibit was the demonstration of the dial telephone. Here the equipment was arranged so that the visitors could actually see the various operations involved in completing a dial call. The five principal frames appearing in a dial central office formed the background of the exhibit, and by means of red lights on each of the frames (except the first or "sender" frame) and lighted signs at each end of the space, the visitor could trace the progress of calls which started from a telephone at the left and were automatically sent through the equipment at 30 second intervals, terminating at another telephone located at the right of the exhibit space. The greater proportion of the individuals who stopped to examine this display—many of them with the exclamation, "Oh, look, here's the dial telephone. I want to see that!"—had the equipment explained to them by a demon-

strator. For this purpose, small booths were provided in the center and at either end of the area. Two telephones were placed at each of these positions and during the course of the explanation a call was actually made from one of the telephones to the other and traced through the various frames by means of small colored lights on the selector rods.

It was intensely interesting to watch the reactions of the spectators as this demonstration progressed. The dialing mechanism was usually explained first to the group of people who had gathered around the attendant's desk, and attention was directed to the equipment in the background: "These five frames constitute the five main frames which you would see in a dial central office. All of them are necessary for completing a single call from one dial telephone to another." During this announcement a number of persons who had stopped more or less casually in the aisle space to look at the equipment would begin to move into the area in order to hear the demonstration. The "sender" frame was explained as an "electrical brain" which stored up the dial impulses and sent them through the equipment at the proper time. Next, the demonstrator would pick up the telephone in the booth and, calling attention to the second or "line finder" frame, would take the receiver from the hook. The light on the rod associated with the line would light and the rod itself would rise and make connection with the calling telephone. At this point the interest of the observers would shift from the attendant to the equipment, and as the central office prefix and then the first two and last two digits of the number were dialed by the demonstrator, heads would turn and eyes would shift from one frame to the next as the call progressed to completion.

When the last digit had been dialed and the appropriate rod in the final frame had risen, the demonstrator would explain that the line of the called subscriber had been reached and that in a moment the telephone on the opposite side of the

desk would ring. When this was announced, there appeared to be a general air of expectancy, which was dispelled with smiles and significant nods when the familiar sound of the telephone bell was heard. After talking with someone near the demonstrating booth, using the telephone connection established through the demonstration frames, the telephones were hung up. As the crowd watched the rods resume their idle position, the demonstrator explained that the equipment on display represented only about one-sixtieth of that found in a central office designed to serve 10,000 telephones.

One of the outstanding features of the dial display was the stimulus it seemed to provide for comments and questions on the part of the visiting public. Almost continuously throughout the day—excepting, of course, while demonstrations were in progress—visitors could be found at the attendant's desk, and the discussions covered almost every conceivable phase of dial telephone service. Typical of the comments were those indicating amazement at the extent and complexity of the equipment—illustrated best perhaps by the remark made by a visitor after a demonstration: "And to think that all this happens when I take the receiver off and dial a number!"

One of the most entertaining of the telephone exhibits, and one which seemed to have a broad popular appeal, was the demonstration of "Scrambled Speech." Some of the changes made in this exhibit in the early stages of the Exposition constitute, perhaps, the most striking examples of the effectiveness of the personalized demonstration and of the importance of the element of "showmanship" in attracting and maintaining the interest of large groups of individuals. The demonstration was carried on in a glass enclosed room just off the southern entrance to the second floor of the exhibit area. On the opening day of the Fair, all the exhibits were being closely watched, and it soon became evident that this particular spot was not getting its proper "play." Early in the afternoon a sign was painted on the entrance: INVERTED SPEECH—A CON-

TINUOUS DEMONSTRATION. The result of this was a distinct increase in the number of persons entering the exhibit. Shortly thereafter the word "inverted" was changed to the much more intriguing term "scrambled" and again the attendance showed an increase.

The demonstration itself, at the beginning of the Fair, was recorded on a phonograph record and the normal speech sounds were reproduced through a loud speaker located at the right of the exhibit area. Immediately in front of this speaker was a microphone mounted on an arm, and at a certain place in the record this arm would swing over toward the speaker, the sounds would be picked up by the microphone, sent through a speech inverter, and the "scrambled" sounds would issue from another loud speaker located at the left side of the room. This method of demonstrating proved rather popular with the visitors, but it was not until the equipment was rearranged so that personalized demonstrations could be undertaken by the attendants that "Scrambled Speech" became a highly attractive feature of the telephone exhibit.

No set procedure was, or as a matter of fact could have been, followed by the attendants in these demonstrations. Usually the general principle of speech inversion was explained as "turning the musical sounds of which the voice is composed upside down." This principle was illustrated by whistling high notes into the inverter, which came out as low notes, and low notes which came out as high. The part of the demonstration most enjoyed by the visitors, however, was that during which words were actually scrambled. The attended might ask someone standing near to say "el, el, el" into the microphone. Amused laughter greeted the "oi, oi, oi," which came from the inverter. During most of the demonstrations a request was made by the attendants for the names of home towns of the spectators. The crowd entered whole-heartedly into the spirit of the demonstration and the number of people from such places as Tuscaloosa, Philadelphia, Kalamazoo, Walla

FIGURE 9. A VISITOR SPEAKS INTO THE "SPEECH SCRAMBLER."

FIGURE 10. INSIDE THE MULTI-CHANNEL DEMONSTRATION.

FIGURE 11. LISTENING TO AN EXPLANATION OF THE CALL ANNOUNCER.

FIGURE 12. THE DEMONSTRATION OF BELL SYSTEM TELETYPEWRITER SERVICE.

Walla and Tallahassee was truly amazing. Although the attendant would not guarantee 100 per cent performance, he was usually able to catch the scrambled sounds coming from the inverter and then by repeating them into the inverting equipment, restore them to the normal form. Very frequently, after the demonstration the attendant was asked for the scrambled spelling of home town names which the visitor wanted as a souvenir of his visit to the Bell exhibit.

During the course of the demonstration, the practical use of inverted speech in providing privacy to conversations on the radio channels utilized for trans-oceanic telephone calls was explained; and the path of a call to a distant point, perhaps in Europe or South America, was traced on a large map immediately in front of the spectators. A number of people usually stayed after the demonstration to ask the attendant questions regarding the nature of the inverting equipment and other possible uses which might be made of scrambled speech, many persons suggesting, some facetiously and some seriously, that it might be a very good thing for party line service. Numerous requests were made for the telephone rates to different foreign cities. One of the most frequent reactions, however, as evidenced by the comments and questions of the spectators, was that which indicated that a great many people had not previously appreciated the fact that steps had been taken to obtain privacy of conversation on trans-oceanic telephone calls.

Around the corners from the dial and long distance areas were located small semi-circular niches, four in all, which contained positions at different types of telephone switchboards. The background of the niches was a dead black. Seated at the position was an operator. The only lighting came from an overhead spotlight which was directed on the operator and covered a small portion of the board. The result was one of the most artistic and arresting effects achieved in the entire exhibit and drew many thousands to listen to the demonstrations. Even when a demonstration had been concluded, in-

stead of moving on to another exhibit the crowd often would remain, and it was frequently necessary for the operator to suggest tactfully, "Just around the corner you will find the dial equipment. I'm sure you would be interested in seeing that." Thousands of people who visited the telephone exhibit took this picture of a telephone operator away with them and with it, perhaps, a new appreciation of the real spirit that lies behind the telephone service.

Demonstrations were conducted at each of the positions and literally thousands of questions were asked on almost every phase of switchboard operation. At the manual switchboard people wanted to know how some specific number was located, how the calls were registered and how they were timed, how the operator knew when the line was busy and how the busy signal was given, whether she could listen in on the conversations, how party-line calls and calls to other central offices were handled, and so on. In the great majority of cases, these questions were prefaced by the recital of some kind of difficulty or some personal experience with the telephone service which the individual apparently had never quite been able to understand.

At the dial special assistance position, which is reached when the subscriber needs assistance in placing a call from a dial telephone, and at the call announcer-call indicator board, used for completing calls from dial to manual telephones, questions were asked about the operation of dial equipment, many of which indicated that the person did not realize that operators were actually required in connection with the dial system. At the latter switchboard, people were mystified by the call announcer and a great many of them actually dialed a number and heard it repeated by the mechanical voice.

At the teletypewriter exchange switchboard, the idea of "typing by wire" was apparently an amazing revelation to a large proportion of the visitors who stopped to hear the demonstration. Many of the spectators marvelled at the intri-

cacies of the equipment and seemed particularly impressed by the fact that a girl could master its operation.

So realistic were these switchboard positions that the spectators would frequently ask, "Is that board actually operating?" and even when assured that it was only for demonstration purposes and was not handling outside calls, would question further, "Then why do those signal lights keep coming up in front of you?"

Directly inside the northern entrance there was a demonstration of the multi-channel telegraph, in which twelve messages were transmitted simultaneously over a single pair of wires which were actually shown coming out of a section of standard telephone cable. Receivers were provided on a ledge located in the center of the exhibit, by means of which the visitor could hear the different pitches of the carrier frequencies of any one of the messages, which he could select by means of a switch. On an oscilloscope at the right of the room the wave form of the messages could actually be seen. Here, too, was a tape-type teletypewriter machine which would type any one of nine teletypewriter messages which the visitor might select.

Something over 300,000 persons actually made use of the receivers in this part of the exhibit during the course of the summer. In demonstrating the equipment and explaining how twelve messages could be sent at once over a pair of wires, the attendant usually used as an analogy the tuning of a radio set which makes it possible to pick one out of a number of radio programs which might be on the air at the same time. Numerous questions were asked about the technical aspects of the demonstration, particularly by younger men and boys of high school age, who seemed to be technically inclined or who had some knowledge of telegraphy. Many people were surprised to learn that this system was actually in practical use and that a single pair of wires could carry several telephone conversations as well as code messages without interference.

Directly below the multi-channel exhibit on the first floor

was additional Bell System space devoted to a display of telephone equipment for home and office use and, in addition, certain of the research developments, including the artificial larynx, a floating steel bar, "delayed speech," a photo-electric cell, and so on, which were brought from the Bell Telephone Laboratories. Here again the effectiveness of the personalized demonstration was strikingly illustrated. Demonstrations of this apparatus by an attendant brought large crowds into the area where they could see and discuss with other attendants the telephone equipment on display. There was no attempt made to do any actual selling; rather, the effort was merely made to familiarize the visitor with different kinds of telephone equipment so that he would have a better idea of what was available if a need should arise in the future. During the course of the summer, at the request of visitors, several hundred appointments were made for home demonstrations of the Western Electric Audiphone for the hard of hearing.

Just south of this area, on the first floor, was a second space containing a number of exhibits designed to acquaint the public with services rendered by the Bell System in the field of long distance communication primarily for business purposes. Hundreds of demonstrations of Bell System exchange teletypewriter service were given by teletypewriter operators during the summer, for which two machines were provided which could be connected in the regular manner through the teletypewriter exchange switchboard on the second floor. Another popular feature displayed in this exhibit area was an oscilloscope which showed the wave form of musical notes and speech sounds. Connected to the oscilloscope was an ordinary handset telephone which could be used by the demonstrator in explaining the function of the apparatus in the development of telephone transmission. Great amusement was afforded the spectators, who, by speaking into the transmitter, were able to "see" their own voices. This setting provided an excellent opportunity for the attendants to discuss with interested per-

FIGURE 13. THE LOCAL COMMERCIAL EXHIBIT AREA ON THE FIRST FLOOR.

FIGURE 14. LISTENING TO A DEMONSTRATION OF THE ARTIFICIAL LARYNX.

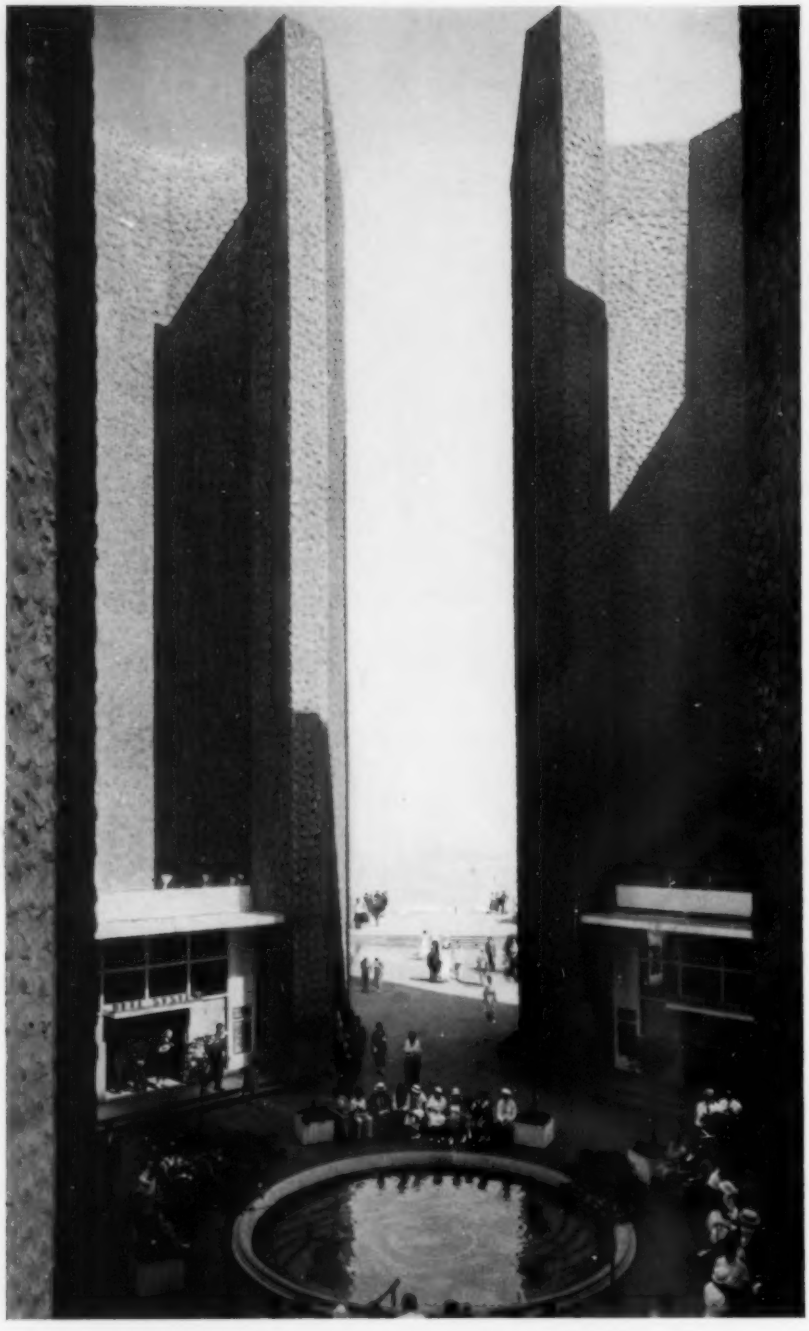


FIGURE 15. THE GREEN TOWERS AROUND COMMUNICATIONS COURT, SHOWING THE TWO BELL SYSTEM PAVILIONS.

sons the possible application of the equipment demonstrated to individual business problems.

Directly outside, and between the Hall of Communications and the lake shore, was Communications Court; and judging by the enthusiastic comments which were made by the visitors, it was apparently one of the most attractive spots on the World's Fair grounds. The Court itself was formed by four large green towers, in the center of which was a circular pool inlaid with a mosaic design emblematic of world-wide communications. Two of the towers contained the institutional exhibits of the Western Union Telegraph Company and International Telephone and Telegraph Corporation. In another of the towers was located the historical exhibit of the Bell System, a number of institutional dioramas, and an electrical echo by means of which the visitors could hear a perfect delayed reproduction of their own voice. This echo afforded great amusement to the visiting public and especially to those people waiting in the pavilion to receive their tickets for the souvenir long distance call. The other tower was used as the executive headquarters and contained registers for Telephone Pioneers and guests of the exhibit. These registers contain many distinguished names and will become a permanent and important part of the record of the telephone exhibit at A Century of Progress Exposition.

The operation of the telephone exhibit was under the direction of Dr. Sergius P. Grace, Assistant Vice President of the Bell Telephone Laboratories, who was the executive representative of the American Telephone and Telegraph Company at the Exposition. Assisting Dr. Grace was Mr. H. S. Hanna as Director of Exhibits, and as Engineer of Exhibits, Mr. R. L. Shepherd, who remained in charge while the exhibit was being dismantled at the close of the Fair.

To care for an average of something over 37,000 persons a day and to maintain the complicated telephone plant at the exhibit was a tremendous undertaking, which required a sys-

tematic plan of operation and an adequate force of attendants and technical men. Throughout the day about 35 persons were to be found on duty at the telephone exhibit. Since the operating period ran from ten in the morning until ten in the evening every day during the Exposition, three shifts were necessary to keep the exhibit in full operation at all times. The demonstrating staff, selected largely on the basis of personality, ability to talk with people, and knowledge of the equipment and services which were to be demonstrated, was chosen largely from the regular employees of the Illinois Bell Telephone Company and some were also selected from the personnel of the Chicago offices of the Long Lines Department. To maintain the telephone plant at the exhibit, much of which consisted of delicate laboratory apparatus and rather specialized telephone equipment, a skilled technical force was recruited from the Illinois Bell Telephone Company and also from the Western Electric Company in Chicago. A course for the staff, covering a period of about a month, was conducted prior to the opening of the Fair. In this course instruction was given in fundamental Bell System policy and on matters relating to telephone operation which were considered as those most likely to be raised by the visitors to the exhibit.

The many favorable comments of the visitors are testimony to the intelligent and considerate treatment they received from the exhibit personnel. It was recognition of this splendid public reaction which Mr. Walter S. Gifford, President of the American Telephone and Telegraph Company, expressed in the following telegram sent to Dr. S. P. Grace at the close of the Fair:

"Will you please express to those who had to do with presenting the Bell System exhibit so favorably to the public my deep appreciation of a job well done. Measured by the innumerable compliments received, you and your associates from the various branches of the System have reasons to feel proud of your splendid accomplishment. The exhibit thrilled me and

I am sure it entertained and impressed the millions of people who made it a part of their tours of the Century of Progress."

A broad vision and years of careful planning lay behind the creation of the exhibit. Effective organization and keen understanding of human nature made it possible to give millions of individuals a new vision of the achievements which have made nation-wide telephone service a reality. There was something at the telephone exhibit for persons of all interests, but underneath was a common message which five million visitors took away with them. They learned about telephone progress, yes; but they learned in addition that the real story of telephone service as exemplified by the Bell System exhibit is a story of progress in human relations. They sensed that the telephone business deals in the most priceless of all commodities: human contacts; and that the essence of telephone service is not machines but men.

Rather late one evening along toward the end of the Fair, an old lady, walking with a cane, came into the office of the exhibit.

"May I talk with the man in charge of your exhibit?" she asked of one of the attendants. "I promise not to take much of his time."

She was taken to the desk in the center of the office. Here is her story:

"I hope I'm not causing you any trouble," she started rather nervously, "but I did want to make a very special request. I know that you allow only one of the free long distance calls to an individual, but I was hoping in my case that you might make an exception. I know it's asking a lot, but it would mean so much to me if it could be done.

"I have a sister in Los Angeles who is a cripple. We have not seen each other for twenty years. Our circumstances are such that we shall probably never see each other again.

"When I first learned that the Telephone Company was letting its visitors make free long distance calls, I wrote to my

sister and told her that I would call her on October 18. She was to be brought downstairs in her wheel chair that day and I wanted to be sure that she would be near the telephone. How long I might have to wait for my card and she for the telephone to ring made no difference to either of us.

"I made the call that day," she said, reaching into a small handbag for the souvenir card which she had been saving and which she placed on the desk. "My niece answered the telephone. I had made a dreadful mistake. In my letter I had said the 25th instead of the 18th. My sister was upstairs, and before she could be brought down I knew that my three minutes would be up. There was nothing we could do; I was dreadfully disappointed."

During this part of the conversation, the card which contained the name and telephone number of the sister had been quietly taken from the desk. In the background a voice could be heard: "Long distance, please. I want Los Angeles, California . . . "

"I know it would be taking someone else's time who might be making a call but it would mean so much . . . "

A quiet voice interrupted, "I've been getting your sister in Los Angeles. She will be downstairs in just a minute—here she is now."

The hand that took the telephone was trembling.

C. T. SMITH

Editor's Note: Mr. Smith is of the staff of the Chief Statistician of the American Telephone and Telegraph Company and was assigned the work of recording and analysing data relative to results of the Bell System Exhibit at the Century of Progress Exposition.

Systems of Long Telephone Lines

AS WE review the panorama of progress in the provision of constantly improving means of communication, we consistently find that greater speed is one of the outstanding advantages of each new method.

The telephone makes available such an advantage, in that it is possible by its use for persons who are separated by greater or less distances to be quickly interconnected by wire or radio and to carry on conversations with much the same facility as though they were face to face. The speed with which the connection can be established is undoubtedly an important reason for the rapid growth and present extensive use of long distance telephone service.

But although speed in the conduct of affairs is ever present as an objective, it must be obtained at a reasonable cost and with consistent reliability, if new and quicker methods are to be of value and keep a place in the scheme of things for other than a relatively brief period. Therefore, in the planning of a system of telephone lines, the question of reliability of service plays an important part, not only in the design and assembly of the materials used, but in the broad selection of routes and allocation of circuits to such routes. In the following discussion a few examples will be given of things that have been done with respect to the latter two items in building up the network of longer toll lines operated by the Bell System so that the service is not only generally fast but reliable.

From Single Lines to Alternate Routes

From the beginnings of long distance telephony, it has been the popular thought that service between any two cities involves merely a single line. This is natural enough, for the development and expansion of long distance service in this country was effected by means of such lines stretching south-

ward and westward from the northeastern industrial centers. We recall that the first New York-Boston line was completed in 1884. The New York-Philadelphia line was completed in 1885. The New York-Chicago line was opened in 1892, just ahead of the Columbian Exposition. The first transcontinental line, giving direct connections between the east and west coasts, was placed in service in 1915, the year of the Panama-Pacific Exposition.

The completion of each of these various lines was hailed at the time as "a triumph of modern telephone engineering." They were well designed and soundly constructed and gave excellent service. However, when a sleet storm, tornado, fire, flood or other cause temporarily interrupted the service on any of these initial lines, the service remained interrupted until repairs could be made. As lines increased in length, the exposure to causes of interruption became greater. The very causes of these interruptions often made it of increased importance to the public that telephone communication be available. To help maintain communication at all times, it has been found desirable, therefore, to have, wherever practicable, more than one line between cities and sections of the country and to have the lines so located that storms or accidents which affect the one are unlikely to interrupt service on the other at the same time. We call these additional lines alternate routes. They are usually made up of lines which are direct connections between points other than those located on the primary route. For example, the normal routing of the seven telephone circuits now in the Pittsburgh-St. Louis group is in direct cables by way of Columbus and Indianapolis. An alternate cable route for these circuits is by way of Cleveland, Toledo and Chicago. A brief study of the accompanying maps will reveal that alternate routes have now been made available between most of the important points in the Bell System.

Lines are planned primarily for the handling of business between the points connected and acquire important signifi-

BELL TELEPHONE SYSTEM
Lines of the American Telephone and Telegraph Company and Associated Companies in the United States, connecting with the telephone systems of Canada, Cuba, Mexico, and Western Europe.
C A N A D A
M E X I C O
Gulf of Mexico
Legend

FIGURE 1. DETAILED MAP SHOWING THE LINES OF THE BELL SYSTEM.

cance as alternate routes incidentally or through the working out of plans made in advance with this feature in mind. The southern transcontinental line (by way of St. Louis, Dallas, El Paso and Los Angeles), for instance, was completed both because of the need for additional circuits to the southwest and because of the great responsibility carried by the central transcontinental line (by way of Chicago, Omaha, Denver, Salt Lake City and San Francisco) when it was the only telephone route to the Pacific Coast. One of the reasons for installing the first Philadelphia-Washington cable (1912) was to protect service into Washington which previously had been furnished exclusively by open wire lines.

General Circuit Design

The matter of circuit design becomes of increasing importance when we consider an interconnected system of routes. A specific circuit arrangement which would operate effectively on a direct route between two points might not be satisfactory if changes are later required or if it should be necessary to use it in building up longer alternate routes. It is the history of most industries that changes are required from time to time for numerous reasons, some of which cannot be foreseen, and a design which permits of reasonable future rearrangements in the direction indicated by prevailing trends can have great influence on economy and efficiency of operation.

In toll cable plant, the trend in recent years has been to use uniform or standardized circuit arrangements for new work, as far as practicable; and for the longer cable circuits, say over 200 miles, to use the so-called 4-wire or 2-path lightly loaded circuit which, with existing equipment arrangements, is capable of providing good service through cables up to about 2,000 miles. So far, cable circuits longer than this have not been generally required, but they can be made available when needed. Also, by using combinations of cable and open wire, good service can be given over much longer distances. At

present, the cable circuit arrangements referred to above comprise about seventy per cent of the cable plant of the Long Lines Department. This 4-wire type of cable circuit is only slightly more expensive in first cost than other types of toll cable circuits that might be used for distances somewhat over 200 miles, but the possibilities of economically using combinations of it over various routes, and without too rigid adherence to original planning, in the event of changes in conditions, makes for greater flexibility and better service. It is thus an important factor in making it practicable to use alternate cable routes freely and efficiently, not only in emergencies, but in regular service as may be found desirable.

Modern practice in open wire circuit design has also made practicable the extensive use of alternate routes for both emergency purposes and regular operation. This is due to the fact that we now have circuit arrangements available which might be considered as broadly universal for application in those sections of the country where cable is not justified. An outstanding feature of this practice includes the general use of telephone repeaters, which made practicable and desirable the abandonment of loading on long open wires; and this in turn made possible the present extensive use of carrier telephone systems. This chain of developments brought about greatly improved transmission characteristics and practically removed distance as a limiting factor in open wire telephone circuit layout work.

Thus, in so far as the matter of general circuit design is concerned, we are in the fortunate position of being able to lay out a system of open wire and cable lines interconnecting points throughout the country for direct service but, over and above that, to build up alternate routes economically for use either in emergencies or for regular service with far less regard to distance limitations than was the case a couple of decades ago.

Alternate Routes Used in Regular Layouts

The shortest distance between two points is a straight line connecting those points and, other things being equal, telephone circuits are naturally constructed on such lines. However, the factors of reliability and overall economy very frequently dictate the use of less direct routes. For example, the major part of a direct line connecting New York and Cleveland would pass across northern Pennsylvania through mountainous country where the construction and maintenance of lines would be difficult and expensive. A cable route which is used through Reading, Harrisburg and Pittsburgh, though about 50 miles longer, is generally through less rugged country, directly serves larger intermediate cities, and is the more economical for conditions which have existed to date.

Sections of many lines built for direct service between certain cities may be combined to provide circuits in a roundabout way between other cities where the requirements are not sufficient at the time to justify direct lines. In such cases, the first lines serve as an alternate route to postpone construction until such time as business between the latter cities has grown to a point which will justify economically the construction of a direct line. After the construction of the direct line, the first lines then serve as an alternate route for purposes of protection. To cite an example, service between Chicago and Seattle was provided over the central transcontinental line by way of San Francisco and north to Seattle until the volume of business justified the construction of the northern transcontinental line by way of Minneapolis, Fargo, Helena, and Spokane. Further, a fourth transcontinental line by way of Kansas City, Albuquerque, and Los Angeles was built to handle traffic which was beginning to overload the southern and central transcontinental lines. This new line provides a route between Chicago and Los Angeles which is about 400 miles shorter than that provided by either of the other lines but much

of it passes through a territory where there are few intermediate points to be served, hence its construction and use was justified by the direct business.

The growth of direct lines has been such that there are today practically no large cities in this country which, for telephone and telegraph service, cannot be reached from more than one direction over the Bell System network of open wire lines and cables. This extensive network makes it possible, in many cases, to set up the normal circuits into a given city from more than one direction in order to insure more reliable service. It has, therefore, become the practice, where a second route is available and its length is not such as to make its regular use excessively costly, to divide the circuits connecting two cities between the direct route and the second route in order to insure practically continuous service.

The circuits assigned to the various transcontinental lines are, in so far as practicable, divided between them or routed in such a way as to obtain a high degree of protection to the service. A few examples shown in the following table may be of interest. As future circuits are added, it is expected that there will be a still greater distribution.

Circuits	Total Circuits	Number of Circuits Assigned to Transcontinental Routes by Way of					
		El Paso		Albuquerque		Salt Lake City	
		No.	Length	No.	Length	No.	Length
Chicago–San Francisco	10	2	2920	1	2730	7	2390
New York–San Francisco	6		—		—	6	3210
Chicago–Los Angeles	11	8	2690	2	2330	1	2820
New York–Los Angeles	8	7	3150	1	3210		—
Kansas City–Los Angeles	2	1	1850	1	1770		—
Denver–Los Angeles	7	1	1520	5	1210	1	1210

The majority of these telephone circuits are used for long distance telephone calls. Some are used for transmission of music and speech for radio broadcast purposes. Still others

FIGURE 2. THE SOUTHERN TRANSCONTINENTAL ROUTE NEAR PHOENIX, ARIZONA.

FIGURE 3. ANOTHER TRANSCONTINENTAL ROUTE ABOUT 150 MILES NORTH OF THE ONE SHOWN IN FIGURE 2.

The three routes shown on this and the next page traverse territory of quite different characteristics. Certain circuit groups are divided so that some circuits are assigned to each line. The existence of these alternate routes results in more continuous service.

FIGURE 4. THE CENTRAL TRANSCONTINENTAL ROUTE NEAR SALT LAKE CITY, ABOUT 350 MILES NORTH OF THE LINE SHOWN IN FIGURE 3.

FIGURE 5. TWO CABLES ON ONE OF THE HARRISBURG-PITTSBURGH ROUTES. THIS ROUTE IS THROUGH BEDFORD.

The two cable lines shown on this and the next page are part of an extensive system of cable routes which interconnect most of the large cities in the central and eastern parts of the country. More than 1,000 long distance telephone circuits can be provided by these four cables.

FIGURE 6. TWO CABLES ON ANOTHER ROUTE BETWEEN HARRISBURG AND PITTSBURGH, THROUGH ALTOONA.
This route and the one shown in Figure 5 are separated by about 40 miles at this point.

are used for voice frequency carrier telegraph systems, each of which provides 12 telegraph circuits.

With the growth of the cable network which covers the central and eastern part of the United States, the number of possible alternate routes to which circuits connecting two points can be assigned has, in general, been greatly increased. For instance, between New York and Chicago there are two completely different cable routes and two other partially different routes by means of which service between these points could be taken care of. The first of these completely different routes is via Albany, Buffalo, Cleveland and Toledo, and the second via Harrisburg, Pittsburgh and Terre Haute. Cables interconnecting points on these two routes make available still other possible alternate routes.

There are 63 telephone circuits between New York and Chicago which are used largely for long distance calls between these cities. In addition, there are ten telephone circuits in service between these points which have been specially designed and constructed for transmitting program material for broadcast purposes and fifteen circuits which are used for voice frequency telegraph systems and provide 180 telegraph circuits. Five circuits are set up for use in emergencies. There are, of course, assigned to these same routes many other circuits connecting intermediate cities or cities beyond the terminals of the section.

These 93 direct circuits which connect New York with Chicago are distributed on the various routes in the following manner: Seven by way of Buffalo, Cleveland and Toledo; 64 by way of Pittsburgh, Cleveland and Toledo, and 22 by way of Pittsburgh, Dayton and Terre Haute. Although 86 of these circuits are at present assigned to the same general route between New York and Pittsburgh, they are distributed among the four cables which are available in this section and these cables are so located that in effect they provide more than one route. Between New York and Reading, one of the

cables is underground and three are on a pole line, while two aerial cable routes are used from Reading to Pittsburgh. There are also from two to four cables in the Cleveland-Chicago section located on two separate routes, excepting between Toledo and South Bend, and the circuits are distributed in the several cables.

There are two completely different cable routes possible between New York and Boston and partially different routes in some of the sections. One of these routes is by way of Hartford and Providence and is 230 miles long. A second partially different route is by way of Hartford, Springfield and Worcester and is almost exactly the same length as the first. The cables are entirely underground excepting for the section between Springfield and Worcester on the latter route. A third route is by way of Albany, Springfield and Worcester and, although about 100 miles longer than the other two, serves as an alternate route to protect service normally routed over them.

Between New York and Washington, the normal route is by way of Philadelphia and Baltimore in underground cable. There is, however, an alternate cable route by way of Harrisburg and Baltimore.

As pointed out earlier in this article, alternate routes are frequently used to defer the construction of more direct routes until the volume of business is sufficient to make the construction of a direct route economical. This method of deferring construction projects is used to a large extent and it is one of the factors permitting the furnishing of good service with the least cost. Examples of this practice are mentioned below.

A section of the central transcontinental line west of Omaha is completely filled with circuits. To defer the construction of an additional line or some other form of relief, some circuits which would normally be assigned to that line have been assigned to the southern transcontinental lines. Although the circuits are somewhat longer than those on the central route, the existence on these other routes of pole line capacity and

circuits which are temporarily spare makes their use in this manner an economical procedure.

The construction of a toll cable between Terre Haute and St. Louis was deferred for about three years by using facilities that had been provided for future growth over cables between Terre Haute, Danville, Springfield and St. Louis.

The direct route for business from Chicago to Florida points is by way of Cincinnati or Louisville through Atlanta to Florida. However, the addition of facilities between Cincinnati, Louisville and Atlanta has been deferred by routing part of the Chicago circuits to Florida points over toll cable conductors to Baltimore and through Washington to the south, using facilities that are temporarily spare on this alternate route.

Alternate Routes Used in Emergencies

When a direct route between two points fails because of storm damage or other causes, the existence of an alternate route makes possible the quick setting up of emergency circuits so that service may be restored without waiting for the repairs to be completed on the direct route. This function of an alternate route is of great importance in maintaining uninterrupted long distance telephone service. For instance, should a portion of the central transcontinental line be destroyed by a storm, it might be hours or even days before service between New York and San Francisco could be restored, if this were the only route available. Actually, however, the service is usually restored in a few minutes by using circuits over one or both of the other transcontinental lines to Los Angeles and the Los Angeles-San Francisco cable between the latter two points. Such a circumstance has occurred a number of times. On November 20, 1930, an unusually widespread, wintry storm broke down sections of three of the transcontinental lines, leaving the southern line, by way of El Paso, as the only connection to the Pacific Coast. So great was the loss of circuits

that it was, of course, impossible to reëstablish all of them over the route through El Paso, but every possible facility on that line was used. Enough circuits were established, however, so that telephone and telegraph service was continued to points on the Pacific coast.

An unusually roundabout emergency circuit was set up for a period of five days in December, 1931, when, because of the destruction by storms of a short section of line in an area difficult of access between San Francisco and Seattle, a circuit was set up by way of Chicago, using the central and northern transcontinental lines. The normal length of a San Francisco-Seattle circuit is about 900 miles, but the emergency circuit was about 4,800 miles long.

The normal route for the 28 circuits between Chicago and Minneapolis is over cable and open wire lines through Milwaukee and Madison, Wis. The route which protects this service is that via cable to Davenport and north through Waterloo over the Davenport-Minneapolis line. There have been numerous instances in which this route has provided the only service between Chicago and Minneapolis, because of failure of the more direct routes due to storm damage.

Another instance of the use of alternate routes for the emergency reëstablishment of service occurred at the time of the opening of service to Mexico City, September 29, 1927, by President Coolidge and President Calles. For the purposes of the opening, circuits had been set up between Washington and Mexico City by way of St. Louis and Dallas. A few hours before the official opening time, a failure of the wires occurred near St. Louis, due to a tornado. An emergency circuit was immediately set up by way of Atlanta, New Orleans and Dallas, and another from Chicago via Omaha and Kansas City. These routes were selected as reports indicated that they were well outside the storm area. The program was carried out without any delay, using the route via Omaha, and most of the speakers, of course, never knew the difference.

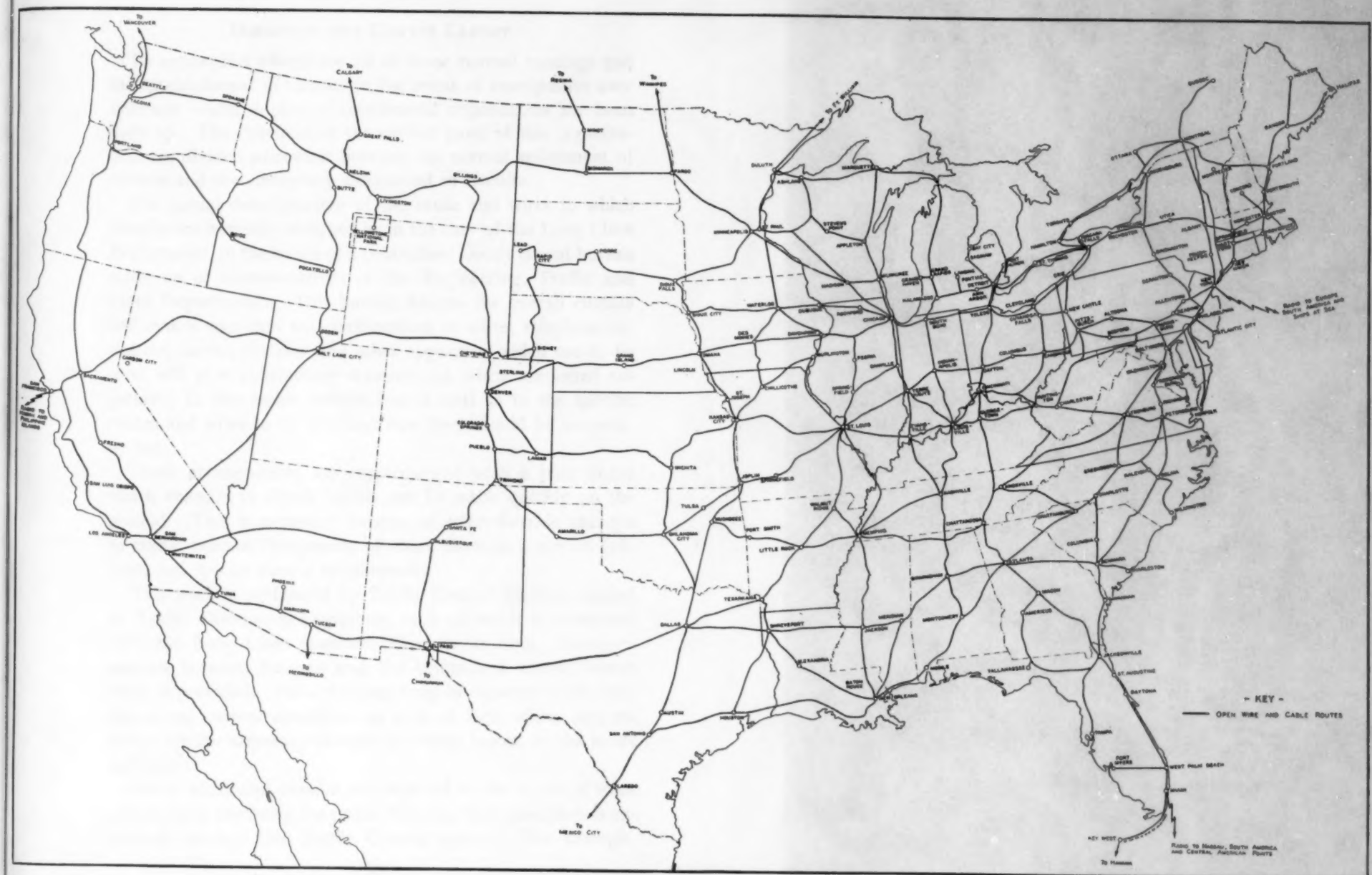
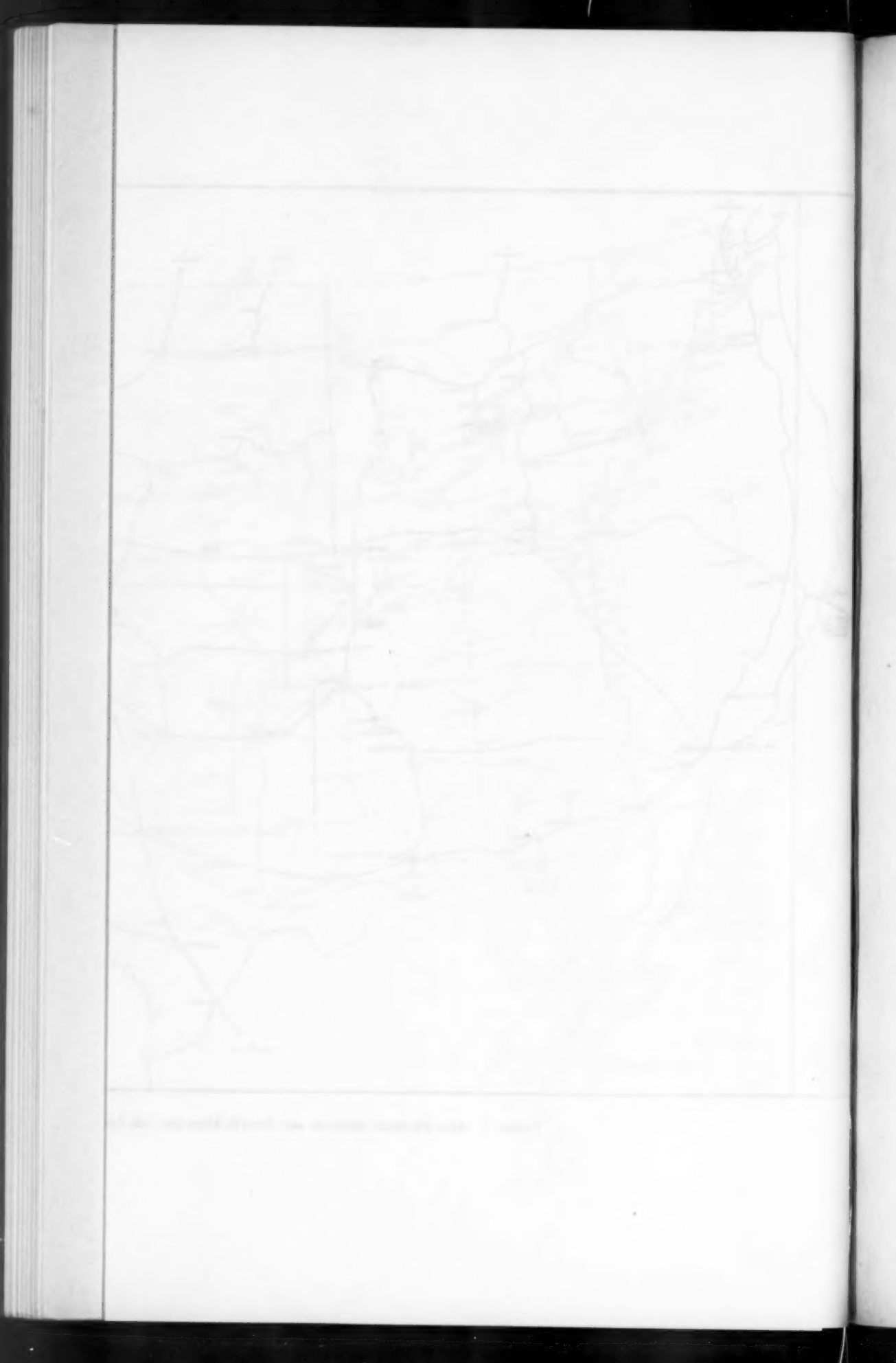


FIGURE 7. MAP SHOWING SOME OF THE ROUTES USED FOR THE LONGER BELL SYSTEM TELEPHONE AND TELEGRAPH CIRCUITS.



Directing the Circuit Layout

To accomplish effectively all of these normal routings and the establishment of circuits in the event of emergencies over alternate routes, a plan of coördinated organization has been built up. The functions of the various parts of this organization are divided somewhat between the normal assignment of circuits and the emergency assignment of circuits.

The actual determination of the route and wires to which circuits are normally assigned is, in the case of the Long Lines Department, in the hands of a centralized circuit layout bureau made up of representatives of the Engineering, Traffic and Plant Departments. This bureau designs the overall circuits and makes sure that the combinations of wires, telephone repeaters, carrier systems and other apparatus which are to be used will give satisfactory transmission when connected together. It also issues written instructions as to the specific routes and wires to be used and how they should be interconnected.

These arrangements are supplemented with a plan under which changes in circuit layout can be made quickly on the ground. This is necessary because of unpredictable changes in traffic volume (frequently of short duration), circuit failures, and special service requirements.

This work is performed by Traffic Control bureaus located at Traffic Division headquarters, each of which is connected with the Long Lines operated offices in its area. Interconnection between bureaus and the centralized circuit layout force is provided. These bureaus keep in constant touch with the actual current conditions at each of their offices and arrange for the necessary changes in circuit layout as the needs indicate.

When additional circuits are required as the result of some major event involving the public interest, their provision is expedited through this Traffic Control system. For example,

immediately following the southern California earthquake in March, 1933, the circuit layout from Los Angeles to the east was increased quickly from 45 to 79 circuits, or seventy-five per cent. Demands for service were, of course, extremely heavy. The first banking holiday in March, which came without prior notice, made necessary an increase in circuits at Detroit from 187 to 262, or forty per cent. At Cleveland, a few days later, the circuit layout was increased by fifty-eight per cent. From then on, the layout between other cities was progressively increased by joint action of the Traffic Control bureaus and the centralized circuit layout unit in New York. The total additions during the three weeks of the emergency amounted to 1,300 circuits, and affected the layout to 180 cities. The possibility of using alternate routes freely in cases of this kind is, of course, an important factor in maintaining good service.

For each long distance circuit set up, an office of the Plant Department, usually one of the terminal offices of the circuit, is made responsible for the over-all conditions of that circuit from the standpoint of transmission efficiency. This responsible office is called the Circuit Control office, and it directs in a general way the testing and trouble clearing on the circuit. It is through this office that the Traffic Control bureau directs any temporary changes which it wants made in the layout of the circuit. This office also directs, in accordance with orders from the circuit layout bureau, the original establishment of circuits on their normal routes. The intermediate offices along a circuit are responsible for the detailed maintenance of the wires and equipment which make up the circuit. They perform regular checks and tests on both, in order, so far as possible, to anticipate and prevent troubles. When troubles do occur, these offices, under the direction of the Circuit Control office, assist in locating the trouble and in restoring service by setting up emergency circuits over spare wires on the same or other routes.

Conclusions

Considering the layout of long telephone lines in this country as a whole, we have, therefore, advanced from the stage where cities and even large sections of the country were connected by only one route. We no longer refer to the New York-Chicago line, but rather to a system of lines connecting these points, designed so as to give good transmission and to be as free as possible from interruptions and with the component routes so separated that a complete interruption to one is unlikely to affect the others. In 1915, a single transcontinental line with a maximum layout of three circuits provided the telephone communication between the Pacific Coast and the eastern part of the country. There is now a system of transcontinental lines. Four of the routes extending to the Pacific Coast are widely separated and traverse the country between the Canadian and Mexican borders. Each carries many telephone and telegraph circuits and the lines are so interconnected that a high degree of security can be obtained. These and other examples referred to may illustrate the progress which has been made in developing a system of long telephone routes and the advantages which such a system affords in the day to day rendering of service to the public.

J. J. Pilliod

The Rôle of Drop Wire

THE outside plant structure known in telephone parlance as the "drop" is the insulated pair of aerial wires that connects a cable or open wire circuit with the "inside" or house wiring of a subscriber's telephone.

While drop wires in some form are as old as the telephone business itself, the drop wire's history lacks the glamor that surrounds the more spectacular elements of telephone plant and it has received little recognition in telephonic literature. Yet of the thousands of inanimate things involved in the romance of the telephone, few have had a more interesting part than drop wire. It is unique in its adaptability to a wide variety of uses, and these many uses have kept it in close contact with human affairs when events large and small were marking epochs in the lives of many telephone people. Besides its usual function of connecting aerial cable circuits to telephones, it is called upon to serve in the place of open wire and cables for the quick restoration of service after storm breaks and floods, to perform as temporary patching lines for the purpose of avoiding interruptions to service during construction and reconstruction work, and to serve temporarily as submarine cable and as line wire extending beyond the ends of cables.

Difficulties Imposed by Its Environment

Drop wire is also unique in the diversity of the hardships it undergoes, which in some instances induce human hardships as well. In the well designed aerial cable plant every element of the plant, including drops, is safeguarded as far as practicable against injury caused by existing or probable future conditions of its environment. The poles have been selected as to size and height and have been carefully located; the cable has been fastened at predetermined heights on the poles and guarded by

location and certain devices from wear or other injury by tree limbs, power wires and other things; terminals have been joined to the cable at certain poles which are most suitable for drop wire connections, and the drops are run from these points to subscribers' buildings by routes that introduce the least practicable hazard to the drops. The drops, however, are installed after the cable and terminals are in place, some of them years afterward when the environment of the drops may have undergone an important change. Such a change may be due to the planting or growth of trees, changes in other wire services, or changes in the distribution of telephones. Whatever the cause, it is common to find that many drops necessarily have a very unfavorable environment, where they are subjected to great abuse from which the more massive elements of plant, such as cable, remain relatively free.

It is fair to state that, as compared with cable and most of the other elements of plant, the drop has the most vulnerable position. Unlike the telephone and other inside equipment, which are well housed and protected against the rigors of outdoor exposure, and unlike the cable which, though exposed outdoors, is systematically engineered into place and strongly supported, the drop must support itself outdoors in the gap between the cable and the building that houses the telephone, no matter whether the span be short or long, over, under, around or through trees or other obstructions. By the very nature of the service it must render, it often must endure much abuse.

The form of abuse which causes more drop wire trouble than any other is abrasion, which is best illustrated by branches of trees rubbing against the wire. This wears off the insulation and reduces the insulation resistance of the wire to ground, especially during wet weather when the leakage may make the circuit inoperative. Then it becomes an element in a human drama, a part of which may be heard but not told, for it is then the troubleman goes out into the wetness to find and clear the

trouble; and if the sun comes out and dries him off, and thus relieves his physical discomfort, it may also dry off the drop, causing the trouble temporarily to disappear, which adds to his difficulty in locating it. Trouble of this kind has been combated practically since the beginning of the telephone business, particularly by the specialists concerned with development work. It apparently began even before the drop received its present name.

Origin of Its Name

It is found that the very early records refer to drops as "leading-in wires," "cut-in wires," or merely "exterior wires." However, at least by 1895 the term "drop" was being employed, for we have a record of its use by the Wire Department of the City of Boston in the following rule promulgated by it in that year:

> "To be brought below the roof of a building, the drop must commence at the top of the same building and run straight down between and not in front of windows, hoistways, etc., and as near the wall as the character of the service will admit."

This rule suggests that "drop" as applied to wire was then a well known term and that it originated in connection with house top distribution. Another one of the rules makes it clear that the term was also applied to electric light and power wires. The house top distribution referred to was the truly overhead system which is portrayed in Fig. 1. The line wires were run from building to building and block to block on fixtures such as these. Some of these fixtures were thirty-six feet high and carried two hundred or more wires.

Major Development Steps

It appears that originally there was no distinction between drop wire and line wire and that drops were merely bare line wires dropping from the line to the buildings. It was soon found, however, that wet tree limbs with which they were often

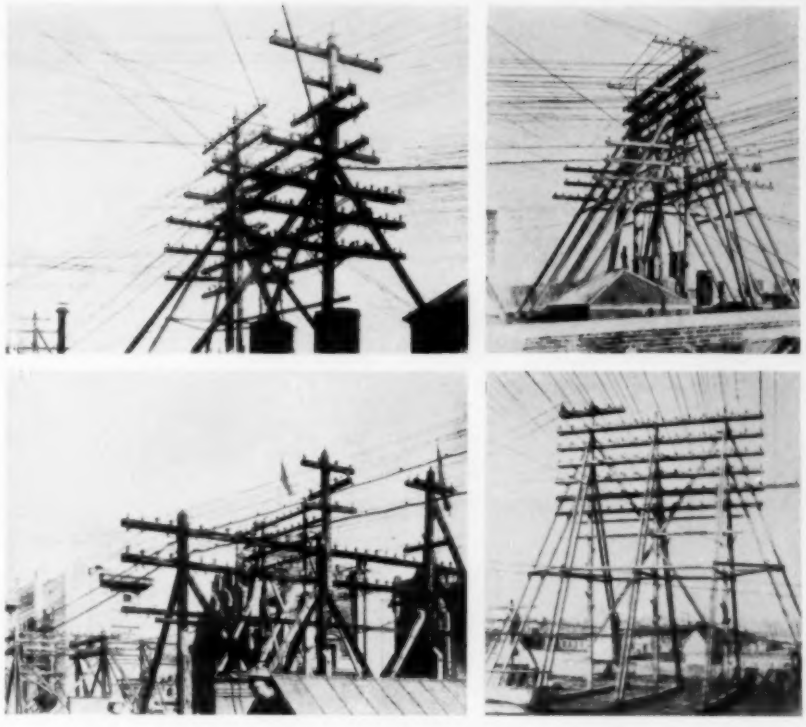


FIGURE 1. ROOF STRUCTURES IN BOSTON, MASS., IN THE EARLY '90's.

These photographs were taken from the Annual Report of the Boston Wire Department for the year 1894. In a later report it was estimated that there were, in the year 1894, 14,000 roof fixtures of all kinds in that portion of the City of Boston north of Dover and Berkeley Streets.

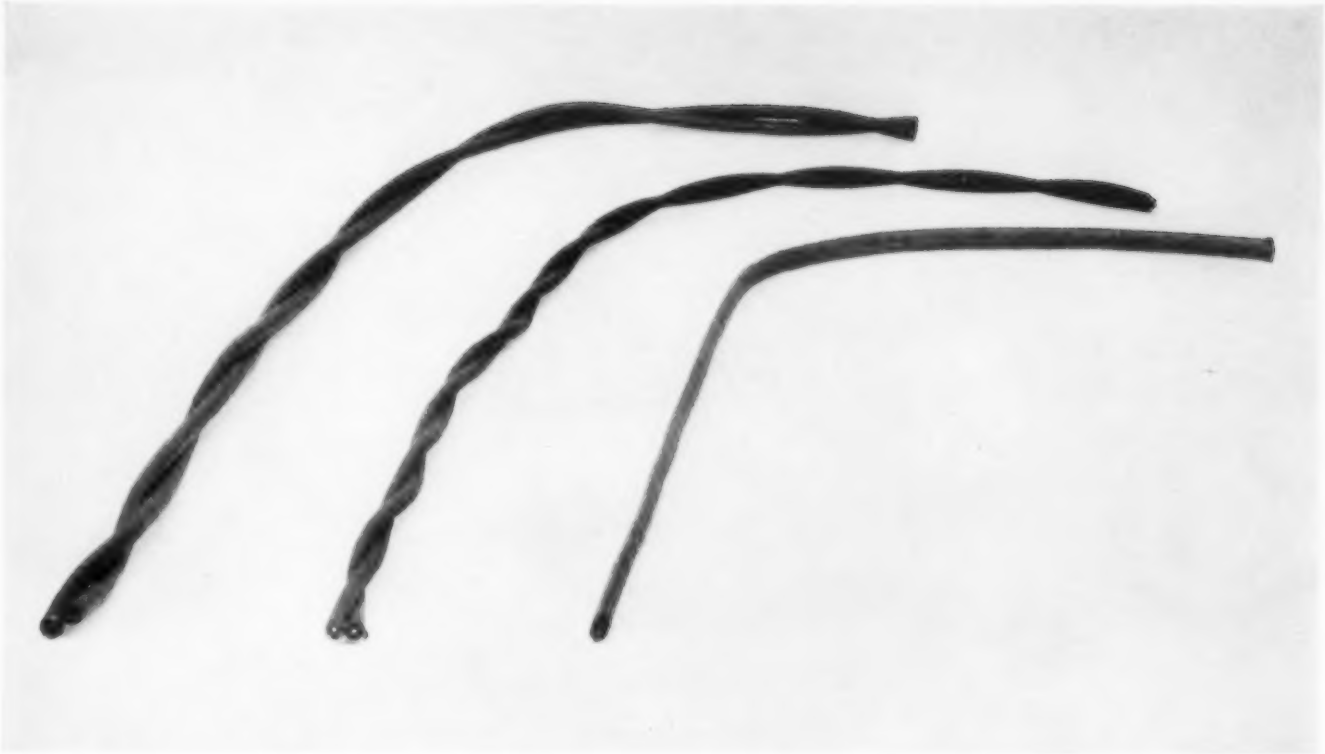


FIGURE 2. THREE STAGES IN THE DEVELOPMENT OF DROP WIRE USED IN THE BELL SYSTEM.

Left: No. 14 B. & S. gauge hard drawn copper twisted pair. Center: No. 17 B. & S. gauge bronze twisted pair. Right: No. 17 B. & S. gauge bronze parallel.

in contact caused them to work badly. Troublesome tree conditions were also encountered in other parts of the lines and it was thought that the leakage troubles could be avoided by using rubber insulated wires where tree contacting could not be avoided. In the early '90's several different kinds of wire were being experimented with, tending toward the unified practice of all-insulated wire drops, and in 1896 the American Bell Telephone Company issued specifications for hard and soft drawn copper wire with rubber insulation. They covered four sizes of wire, 165, 104, 080 and 064 (expressed in mils) and provided "when desired" for laying the wires "up in pairs, either twisted or straight." The year 1897 saw rubber aging tests being made in the American Bell laboratory at Boston. Climatic tests were also used, and comparisons were made between accelerated laboratory tests and the test of actual service.

The records indicate that twisted pair became an American Bell standard in 1901, coincident with the issuance of specifications for "Twisted Pair of Rubber Covered Hard Drawn Copper Wires, No. 16 B. W. G. (.065-inch diameter)." It was intended primarily for use through trees and it did not entirely supersede other types of drop wires.

In 1902 the specifications were revised and the gauge designation was changed from 16 B. W. G. (.065 inch) to 14 B. & S. G. (.064 inch). This wire, which was also hard drawn, became known as "14 twist" and it afforded such great improvements in service and handling properties over the several types of wires used previously that those who participated in its early use never ceased to venerate it. It still holds an exalted place in the minds of many pioneers who now occupy positions of all ranks in the Bell System and it would be almost sacrilege for one to deny that it was superlative wire. It may be said, however, that the knowledge of the properties of materials and rubber technology have been advanced during the last thirty years, so that although the early 14 twist may have been

a superlative service wire, its present successor with certain other points to its credit needs no apologist. For one thing, it cost the Bell System during the last five years about $7,000,000 less than 14 twist would have cost. Although the use of 14 twist for drops was practically discontinued in 1910, it has continued to be used to a limited extent for various other purposes.

At about the time when 14 twist came into being, the common form of distribution was rapidly changing from the open wire type to the cable type, and this seems to have caused greater attention to be focused upon drop wire performance. Open wire lines through trees, of course, gave a great deal of trouble, and open wire drops, although an important source of trouble, were not conspicuous on this score; but when open wire lines were replaced by cable, the open wire drops were found to be the most important source of trouble. It was natural, therefore, that 14 twist should have been so cordially adopted. The trend from exchange open wire to cable distribution is disclosed by the following table of approximate wire mileages in the Bell System as at certain year ends:

Year	Miles of Exchange Aerial Wire Exclusive of Drop Wire		Ratio of Miles of Exchange Open Wire to Total Miles of Exchange Aerial Wire
	Open Wire	Wire in Aerial Cable	
1900	420,000	225,000	.65
1905	915,000	1,245,000	.42
1912	1,179,000	3,628,000	.25
1922	1,064,000	6,447,000	.14
1932	1,169,000	17,021,000	.06

Notes: Previous to the year 1911, the plant measurement reports at headquarters showed no separation of Total Miles of Exchange Aerial Wire between Open Wire and Wire in Aerial Cable. The figures of 420,000 and 915,000 miles are estimates.

The Open Wire figures for 1900 and 1905 include a small amount of covered wire along the lead which could not be separated out. The Open Wire figures for the other years are bare wire only. None of the Open Wire figures includes any drop wire.

The first successor to 14 twist for drops was 17 B. & S. G. copper-steel twisted pair, which was standardized in 1910, and

this in turn was succeeded by 17 B. & S. G. bronze twisted pair in 1921. The insulated conductors of these types were separately braided and waxed before being twisted into pairs. The parallel type of wire in which two insulated conductors are covered by a common braid came into System-wide use in 1924. The present standard drop wire is of this type and consists of No. 17 bronze conductors which are coated with tin, insulated with rubber compound, and two such conductors sheathed with cotton braid which is saturated with a preservative and coated with weather and wear resisting pitch and flake mica. It is available with two types of braid covering, one being made of coarser, harder cotton yarn than the other so as to afford needed protection to the insulation against severe exposure to abrasion. This resistant braid wire, as it is called, costs more than the other, but its higher cost is more than compensated for by its greater endurance in the many cases where there is no alternative to running the wire through trees. Obviously, there are many more cases where the path of the drop is, at least relatively, free from obstructions and where the wire with the less resistant braid is the more economical one to use.

Three types of drop wire discussed in the preceding paragraphs are illustrated by Fig. 2. No. 17 B. & S. gauge copper-steel twisted pair had the same dimensions and the same appearance as the bronze pair shown in the center of the figure.

Aside from its physical properties, drop wire is a relatively short-lived part of the plant, being subjected to frequent changes associated with the station turnover and with any reconstruction of the open wire and cable plant, so that a vast amount of it is used year in and year out throughout the Bell System. The record shows that during the five years ending December, 1932, nearly 2000 million pair feet were installed.

The reasons that have led to one change after another in drop wires are, obviously, the need for wire that would be more resistant to destructive influences, and the desire for economy. Mention has been made of abrasion as a cause of

drop wire trouble. It is responsible for more than one-third of the troubles. Development work has gone a long way toward preventing abrasion troubles on wire that has been installed during the last few years, and it is expected that, as the ratio of new type wire to old type wire increases, the relative number of abrasion troubles will diminish appreciably. Other injuries to insulation account for about one-sixth of the troubles. The crushing or shearing of the insulation at points of support or other pressure points is one of these and in this case also development effort has been well spent. Nearly one-half of all the troubles, however, are caused by storms, falling trees, motor vehicles, animals, people, and a wide variety of accidental events which can be affected but little by changing the properties of the wire; and the efforts to reduce such troubles, therefore, have been made in other directions.

Noteworthy Improvement of Rubber Insulation

Rubber compounds such as those used on drop wires throughout the last score or more years are inherently good insulators when new, but until a few years ago all of the compounds deteriorated rapidly, due to oxidation. The engineers of the Bell Telephone Laboratories attacked this problem of oxidation and after much experimenting made marked progress in solving it by developing insulating compounds containing certain substances known as anti-oxidants, which were being used to some extent in rubber tires. A generally accepted view as to the part played by anti-oxidants is that they function as inhibitors and by their presence in the rubber compound retard the normal oxidation or aging rate. They have the practical effect of greatly extending the useful life of the insulating compound.

New Testing Procedure Developed

In development work of this kind, which involves a selection of the best materials from a large number of possible choices, an essential part of the problem is the development of testing

methods. In this case it was necessary to develop an accelerated aging process that would simulate the slow, natural aging of the compounds in the telephone plant, and also special testing equipment and procedures that would give a reliable indication of the vital qualities of the wire, both when new and after accelerated and natural aging. Otherwise, many years would have elapsed before a proper choice could be made and before there could be definite assurance that some detrimental features had not crept in. A quick aging process had already been developed for certain uses in the rubber industry, and this was adapted to drop wire. As in the older work, this recent work followed the formula established in the old Boston laboratory in 1897 of making climatic tests and comparisons between the rapid test and the test of time. A new type of testing machine was also developed to measure the compressive strength of rubber insulation. This machine and the rapid aging process put rubber insulation on a far better basis than it had ever been and this resulted almost immediately in marked improvement in the quality of drop wire insulation. The compressive strength of the insulation as now manufactured is at least twice that of new wire only six years ago, and after aging the equivalent of three or four years in the plant the comparison favors the present wire by a ratio of about 5 to 1. This means that the present wire should be better when it is three or four years old than was new wire six years ago, and it indicates a long useful life for the present wire. When rubber compound of the general type under discussion has greater compressive strength it also has greater toughness, which means greater ability to endure the kinds of abuse to which drop wire is ordinarily exposed.

Improved Protective Covering

Even though the insulating compound has been much improved, it still needs further protection against its worst enemies: rubbing tree limbs, and sunlight. The means for ac-

complishing this is to enclose it in a lightproof covering that will resist abrasion and withstand a wide variety of weather conditions. For many years the covering has consisted of a

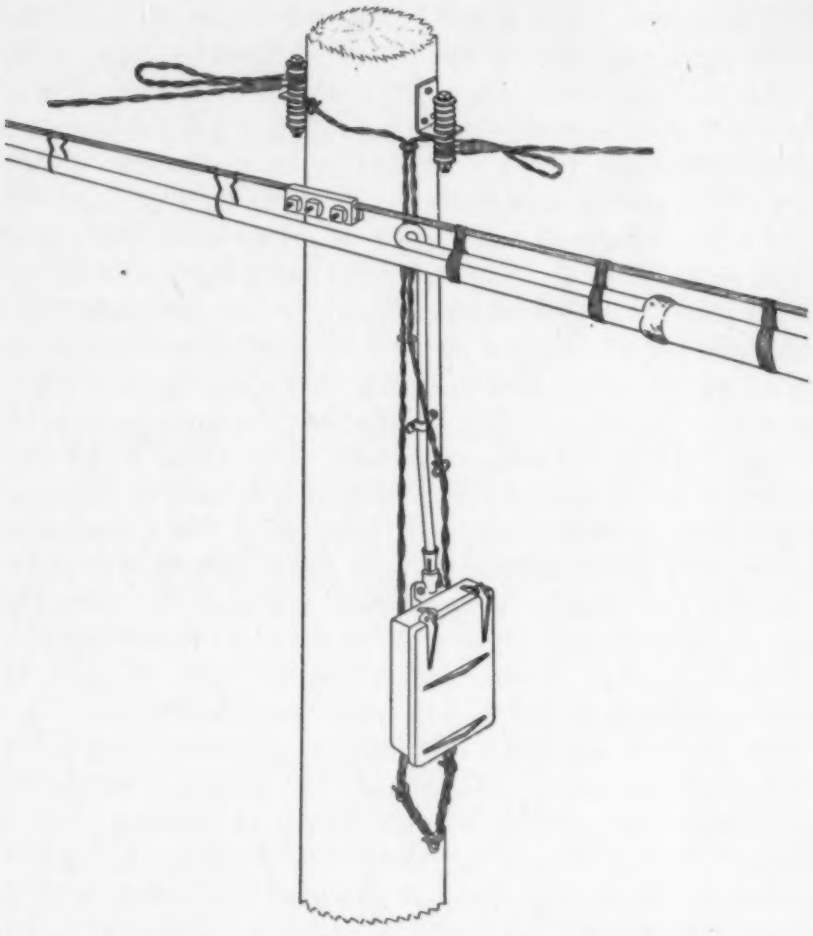


FIGURE 3. DISTRIBUTION FROM AERIAL CABLE TERMINAL ILLUSTRATING THE USE OF TWISTED PAIR DROP WIRE AND DEAD END TIES (NO. 14 TYPE CABLE TERMINAL).

cotton yarn braid which has been treated with weatherproofing materials. These materials and the methods of applying them have undergone a number of changes throughout the years but,

similar to the experiences with insulating compounds, quantitative measurements of results had to come before there could be definitely predictable improvements in serviceability. To

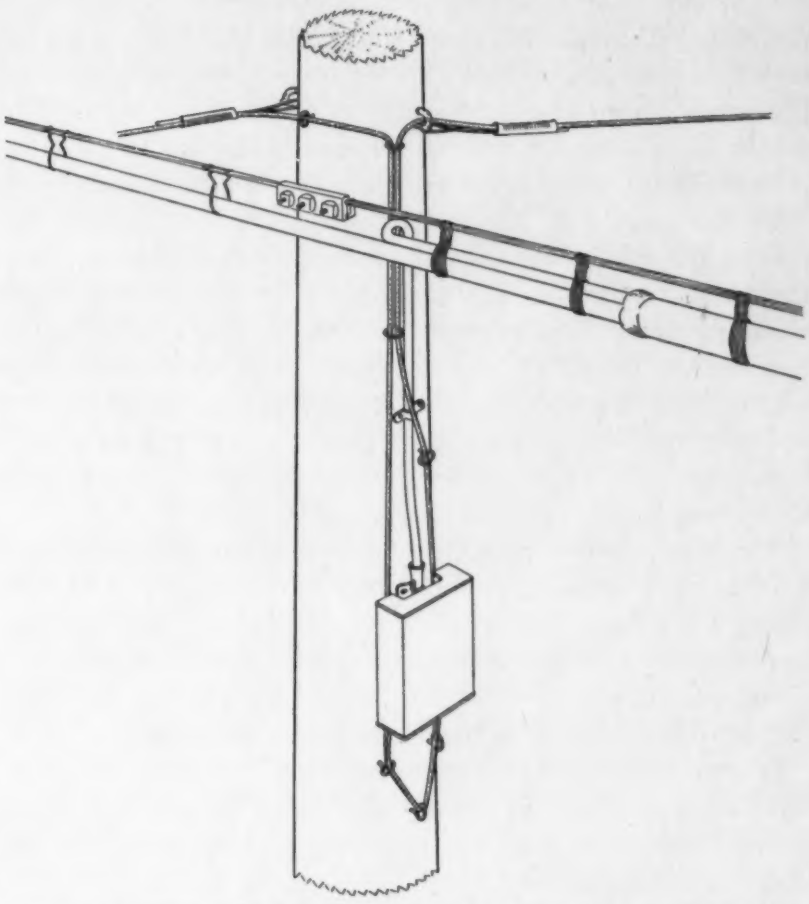


FIGURE 4. DISTRIBUTION FROM AERIAL CABLE TERMINAL ILLUSTRATING THE USE OF PARALLEL DROP WIRE AND ATTACHMENTS (F TYPE CABLE TERMINAL).

this end certain weatherometer and rubbing tests were developed in the Bell Laboratories and by their aid a new system of treatment of the braid was developed which will effect an im-

portant extension to the life of the braid and should improve abrasion resistance as much as five to tenfold.

Conclusion

Only the most important aspects of the rôle of drop wire proper are discussed in the foregoing and, therefore, it should be stated that the solution to the general drop wire problem has not depended wholly upon improvements in the wire. The means for holding the wire in suspension and for terminating it have always been important features and a large amount of work has been done toward perfecting them. It is not the present purpose to discuss that work, but it may be said that these attaching means have also been developed through many stages by which there has been achieved a more nearly trouble free and better looking drop structure. The trimness of parallel drop wire supported by its inconspicuous attachments makes a pleasing contrast with the old style drop with its bracket and looped tie. Figures 3 and 4 represent the appearance of typical terminations of old style and new style drops.

The many unwritten pages of the drop wire's history have in them much of the lives of an army of telephone people, who at times have found it an indispensable aid in restoring telephone service after disasters such as those caused by upheavals of nature, and who at other times have had their souls tried by its failure to surmount its handicaps of environment.

Despite the vicissitudes, however, which are inherent in its function, and which are greater than those of any other item of telephone plant, it has evolved step by step into more and more useful forms.

R. A. Haislip

Communication with Electrical Brains

A MOTORIST, warned by a red traffic light that his road will intersect a main highway, slows down for the crossing. No officer is in sight and the unattended signal still shows red. On his side of the road, a few yards from the highway, his car runs over a narrow ridge of rubber. As the rubber is depressed, his request for permission to cross the highway is transmitted to the mechanism of the traffic signal; a few seconds' delay and then its lights change; the stream of cars is halted and a green light authorizes him to proceed.

In this situation the various actions, the transmission of intelligence and the manifestations of authority, are the same as for a crossing guarded by an officer. The red and green lights replace, respectively, his raised hand and the jerk or wave of the other. The procedure has been standardized. All cars are treated alike and the waiting time is definite. Prejudice and whim have been eliminated, but with them judgment and initiative. There is a calm, consistent handling of the traffic—quite automatic, it is true. A mechanism has been established which receives communications from a human being and, in turn, initiates communications with others.

The operation is very simple. Two contacts, which act as a switch, are pressed together when a car passes over the rubber ridge. The current, which is thereby allowed to flow, energizes an electromagnet. This, in turn, with predetermined delay, moves the switches which change the lights. Another period of delay and the light switches return to their original positions; the cycle is complete.

The mechanism has none of the external characteristics of the robots and mechanical men which appear from time to time at fairs and expositions or are enthusiastically described in the popular press. Such contrivances are usually designed to per-

form mechanically, in response to proper stimuli, certain operations which are appropriate to humans. They are formed in the rough outlines of a man and may look like grotesque and ill-fitting suits of armour which have been fashioned by a pipesmith or sheet-iron worker. Or they may be as carefully modeled as a store window dummy and arranged to move arms and legs. Then they are valuable in window dressing and add some illusion to the scene in which they are placed. At its exhibit in the Chicago Exposition an air transport company used two such dummies in the cockpit of a large cargo-passenger plane. The life-like figures moved the controls and periodically one of them raised to its lips the telephone transmitter of the radio set with which such planes are equipped. As it did so a phonograph spoke words typical of the reports and instructions which a pilot would receive.

That would seem to be the *metier* of the mechanical man: to add reality to educational or advertising displays. When more is attempted, the canons of machine design as well as of art are usually violated. Mechanism loses dignity and effectiveness when forced into unnatural forms. An automobile could be built like a jinrikisha, with its motive power vested in a mechanical man, and the creature be no more illegitimate than is an iron-cheeked man constructed to inhale through lighted cigarettes which are properly placed in its lifeless lips. The traffic signal would gain nothing and cost more if made a biped.

In its case there is no need to ascribe to it any human abilities, neither cognition nor volition. It is an inanimate mechanism. But there may be something more in the situation. The device replaces a human being who would otherwise be present and with whom communication would be held. Two parties would normally be engaged at a guarded crossing: a motorist and an officer. Their necessary communication is limited in amount and is not specific as to medium: words, gestures, meaningless sounds, or displays of lights will serve. Nevertheless, there is communication. The motorist asks and

the officer grants. The latter's cold indifference to impatience on the part of the driver is as definite a refusal as can be expressed in words, and its counterpart in the mechanical system is the steady red light. So far as the motorist is concerned, there is communication—an actual exchange of information. The transmission is two-way, like that of a conversation and unlike the one-way operation of a radio broadcast.

A generally recognized difference between our present civilization and those stages which have preceded is due to the increased speed of transportation, whether of ideas, of goods, or of men. For ideas, if the intelligence is recorded as in letters or must be delivered by a particular person, transportation can take place only at the speeds of miles per hour which are usual for goods and men. When the intelligence can be carried by an electrical wave, its speed may be thousands of miles a second, or even as fast as light. Not only do electrical systems for communication possess this possibility of enormous speed, but also they offer the most convenient medium when the terminals happen to be remote either because of actual distance or because of inaccessibility.

The simplest communication system is that of the early telegraph. In it there is a battery from which current can flow when, and as long as, a key is depressed. This source of current and its controlling key are connected by a pair of wires with the distant terminal; and there, when the current flows, it actuates an electromagnet which moves a lever. It was the clack of this lever striking against metal stops, which limited its motion, that Morse used as an audible signal, which by proper coding could represent letters.

The lever, of course, may perform entirely different services, moving anything which is light enough. In general, the lever is used to close another switch contact which controls a local source of power of generous proportions, sufficient to operate a larger electromagnet or to run a motor. The electromagnet and its lever, which can make or break an electrical connection,

is an electrically operated switch. As such, since it can be controlled from a distance, it becomes an immensely important element in all communication systems and in all instances where a remote control of mechanisms is desired. The device is conveniently known as a "relay."

The relay is an essential element whenever there is communication between man and machine. In such exchange of information the mechanical participant will be found to be a more or less complicated assembly of electrical equipment. The complexity will be due not to the variety of elements, for there are not over a dozen different kinds of elements, but to their interrelation. Just as in a clock movement sequences of operations are established by trains of small gear wheels, so electrical mechanisms are built up by a succession of electrical circuits which mesh or link together. Each circuit, in itself, is as simple as that of the telegraph which was described earlier, or of a doorbell with its battery, bell, connecting wire and push-button switch. Each includes some source of energy—a battery or a power main. And the relay is the point of contact between the various links—the means through which one circuit controls the next.

Relays may be constructed and arranged to perform almost any conceivable operation of closing and opening circuits. In the typical construction, the controlling current passes through a coil of wire which incloses a core of magnetizable material. The resulting magnetism, when current flows, attracts an iron lever, the armature. This armature is moved against the pull of a spring which restores it to its unoperated position when the current ceases to flow. The armature itself usually serves as the movable member of the switch which the relay is to operate. Obviously, then, its motion will close or open a switch, depending upon the position of the fixed member. In general, also, relays are constructed so that the armature in its motion pushes before it several leaves, each carrying its separate contact point. The leaves, which are flat springy strips

of metal, and the armature are all insulated from each other. A number of separate switches are thereby formed; and switching in several independent circuits can be accomplished under the control of the current in the winding of a single relay.

Because of this construction, the device has amazing adaptability in the design of electrical mechanisms. The spring leaves may be assembled to execute in rapid succession a dozen or so independent operations of switching. Also, it is not necessary that these shall be undone when the controlling current ceases, for a relay may be made to lock so that a mere pulse of current, lasting long enough to move the armature, will make changes in other circuits which will persist until some new stimulus, in the form of current, arrives to break the lock.

When this is desired, two similar coils may be wound on the magnetic core. Current in either will keep the lever displaced. One coil is used for the control current and the other for a current which locks. The latter is supplied from a battery, connection with which is made through a pair of contacts operated by the armature. When the controlling current flows, it moves the armature, making or breaking the various contacts which the relay is intended to operate but, at the same time, closing the contacts which supply current to the second coil. The relay, therefore, locks. For its unlocking, in the circuit of the second winding, a pair of contacts must be provided which will open under the action of another relay. Current supplied to this relay will then allow the armature of the first relay to spring back, undoing all its previous accomplishments.

If there is any justification for ascribing human qualities to mechanisms, it arises from the potentialities of this simple contrivance. A stimulus arriving at a human brain may result in an instinctive action, releasing for that purpose certain available energies. That is precisely what a relay does. Unthinking, unreasoning, and instinctive, each relay of a communication system performs its definite and predetermined task in response to controlling pulses, wherever they may originate

A whole sequence of actions may be set off, delays introduced as desired, and action may be limited to the duration of the pulse or steadily continued until stopped by a new stimulus. One relay may control a circuit in which there is a second relay, that in turn a circuit with a third, and so on in an infinite variety of combinations. Each relay in the series, while so doing, may function as the original of a new series; and any of all these branching series may contain motors and electromagnets to turn or push or pull, exerting forces on their surroundings. It is, then, not so inconceivable, although the project would be futile and eminently unpractical, that by the proper assembly of relays there could be constructed electrical equivalents of human brains.

The nearest approach to an electrical brain, that there has as yet been practical occasion for constructing, is the so-called "sender" in the central office of dial telephone systems. The number of mental operations which this sender must perform within itself, and the further number which it must accomplish externally, demand a tremendous assembly of relays. Its designers also developed a mechanism which acts like a whole gang of relays. The device, descriptively named a "sequence switch," can coördinate a complicated series of operations, making them simultaneous when desired or introducing any necessary interval; and any of the operations may be arranged to repeat itself periodically, like the cry of a human baby, until conditions permit its satisfaction.

In a sequence switch, the two terminals of the circuit which are to be joined are thin strips of metal, so-called "brushes," and rest on a plate of insulating material. If, as the plate moves, a strip of metal mounted on its surface is brought simultaneously under both terminals (i.e. brushes) then the operation of switching is accomplished and the circuit remains closed as long as the motion of the plate does not carry the connecting strip beyond contact with either brush. The plates, which are circular and flat, can be mounted in considerable number on

a common shaft and thus all travel at the same speed. A succession of switching operations may thereby be precisely arranged for a large number of electrical circuits. The shaft is usually driven by a motor to which it connects through a clutch; and the operation of the clutch, in its turn, is controlled through relay contacts.

These switches are simple structures, compact and reliable, and economically produced in large quantities. With relays they constitute the elements of which designers have constructed electrical brains to act in establishing connections between dial telephones.

Arranging mechanisms to connect your telephone—if a dial type—to any other which you desire, in accordance with your dialing of its number, involves a surprising list of difficult and intricate problems of circuit design. Only one of these is of immediate interest. Assume, therefore, that in response to your lifting of the receiver, your telephone line is connected, at the central office where it terminates, with the mechanism which is to find the terminals of the line you wish. How that mechanism became connected to your line; how, like an operator's "number please?," it sent you a tone to indicate its readiness for your instruction; and all the other how's are momentarily disregarded. You dial, usually what corresponds to two or three letters and four or five numerals. The letters, however, are merely mnemonic: each is equivalent to and replaceable by a numeral. The numerals indicate the number of interruptions in the current which their dialing occasions. For each interruption there is, in effect, a transmission from your telephone to your central office of a pulse or spurt of current. These pulses, by their operation of relays, are to select, first, trunk lines to the central office of the telephone you are calling, and, then, at that office, from the thousands of lines there terminating, the particular one you desire.

Two methods of operation are available. The first, which is usual when there are relatively few central offices in the area

of your telephone exchange, involves no electrical brain. It is a step-by-step operation where some selecting mechanism moves once for the first pulse, makes another step for the second and so on, finally arriving at the one of the ten possible positions corresponding to the numeral you dialed. Another mechanism then takes up the task and performs as you dial. Your control of these distant mechanisms is remote, but as direct as your actions in setting the hands of your watch or shifting your automobile gear.

The other method simulates more closely those of ordinary telephony, where an operator receives your instructions and then proceeds to put them into effect. It is the one which engineering studies have indicated as better adapted to service in those metropolitan areas where there is congested the largest number of central offices.

It is such exchange areas which explain the practical necessity for the adoption of machine switching. Imagine yourself, for example, in an anonymous city which, with its immediate suburbs, has a million telephones. Divide these evenly into central offices each with ten thousand lines. There are then one hundred such offices. You may call a party in any of these, and your operator must know how to reach it. It is economically inefficient to provide trunks connecting your office directly with each of the other ninety-nine; and each of those, similarly, with all the others. Some offices must be reached through others.

However it is all arranged, there will be required at an operator's position an array of equipment, almost bewildering in its amount, from which she must select the appropriate keys for signaling to the distant central office to which your call is directed. How far she can reach to right or left, and how high, limits the amount of equipment she can handle; and the complexity from which she is to select must not exceed that with which she can deal promptly and accurately. Such mental and physical limitations years ago indicated an approaching

day when many of the switching operations of telephony would of necessity be mechanically performed.

No less human effort might be required in the total, but it would be expended first in design and development, next in manufacture and installation, and thereafter in the maintenance of immense and complicated aggregates of equipment. Years of invention and test produced the "panel system," with its electrical brain. Such work, however, is never complete, for new requirements arise, and opportunities for improvement and increased economy always attract the engineering mind; so the development work continues unslackened.

In the panel system for dial telephony—which is so-called because the terminals of lines and trunks are arranged in large vertical panels—the electrical brain replaces in typical functions that of a human operator. Unlike the step-by-step system, the selection of the desired line is not made directly under your remote control as you dial. Instead, the instructions involved in your act of dialing are recorded, within the equipment of the electrical brain, in a set of circuit conditions which are established by the pulses you dial. This corresponds in function, although obviously not in mechanism, to recording in the brain of an operator.

On the basis of those instructions, now comprehended as a whole, the electrical brain then proceeds. First it must determine how to route that particular call. In the telephonically congested areas where the panel system is employed, the traffic information is too voluminous for prompt guidance of human action; and if an operator handled the call she might have to consult a card of instructions. That, similarly, the electrical brain must do. For a fraction of a second, therefore, it connects itself to an electrical equivalent of an operator's traffic manual. In that instant certain of its relays are operated, its internal circuit conditions are correspondingly changed, its mind is now clear and it knows what to do. It then proceeds by relay and sequence switch to actuate equipment, first in its

own central office and then in one or more distant offices, which will make the selection of line terminals required to complete your call.

In response to stimuli from the electrical brain, a sequence of selection is made, first of trunk line to the proper central office and there of successively smaller groups of lines until the final selection of the particular line. These actions differ from those performed in step-by-step systems in a way which illustrates also the mental attitude of the electrical brain.

In both cases, selection is accomplished by some moving member which carries one end of a pair of conductors, the other end of which connects to your line. When its motion has brought it to the right trunk or line, it stops and connection is made. The moving member, conveniently known as a "selector," is pushed ahead in the step-by-step system one position for each pulse, stopping when the pulses cease.

In the panel system the electrical brain throws in a clutch, just as a motorist engages his engine, which starts the motion of the selector. This continues steadily until the brain stops it by throwing out the clutch. The interesting mental action is that involved in determining when to disengage the clutch and let the selector stop and make its connection. It is arranged that, as the selector reaches successively each of its possible stopping points, it shall notify the brain of its arrival. The brain then keeps track of its progress and, when the selector arrives at the desired point, stops it. The process is similar to that in train dispatching when a train is sent along a track and its conductor at each way station reports his arrival; at the proper station he is then ordered to take the siding.

Only two have been described of the several functions of the electrical brain in panel-type dial systems. For each telephone call, hundreds of operations are required. These tasks the brain must perform accurately and with more than human reliability. If it fails, it must immediately be removed from service; and, because such devices are expensive, it should be

promptly inspected, readjusted, and returned to service. In the more recently designed forms, therefore, new cerebral functions are being provided.

Should one of these devices fail—incidentally, they are known as "decoder senders"—it will, of its own action, disconnect itself from the line of the subscriber whom it is answering and report to a maintenance man. Even more: for his information it will print on an electrical typewriter the number of the operation at which it failed. Could more human intelligence and efficiency be demanded of any organism than that it should quit work when diminished powers endanger its further acts, call for help, and accurately state its symptoms for diagnosis?

JOHN MILLS

Editor's Note: The article above is a chapter of a book, "Signals and Speech in Electrical Communication," which is announced for early publication.

A Census Portrayal of the American Family

IN the marketing of household commodities and utilities in any area, the group of persons comprising the family is often considered the fundamental population unit on which to base estimates of potential sales of goods and services for the home. In the general type of population problem usually encountered in Bell System studies, the family is perhaps more significant than the individual, particularly in measuring the residence market and in calculating the degree of penetration of this market realized by the telephone industry. Therefore, a thorough understanding of the composition and characteristics of the average American family, as well as a knowledge of the number and distribution of total families, as shown by available Federal Census data, are essential in any comprehensive population study or market survey.[1]

Composition of the Family

In the 1930 census returns, the term "family" is limited in the main to so-called private families, excluding economic or quasi-family groups—institutions, hotels, boarding houses, etc. —which had been counted as families in previous censuses. The elimination of the institutions and other quasi-family groups makes the reported "family" more representative of the typical domestic household, for while the average number of persons per private family in 1930 was four, the corresponding size of the economic family was nearly ten times as large.

Average Size of Family

The number of private families in the United States on April 1, 1930, was slightly in excess of 29,900,000, while the

[1] The plan of the Census Bureau provided for the collection and tabulation of family data in 1930 on a much more pretentious scale than had ever before been undertaken. Revised definitions and classifications, together with several new inquiries of interest, were introduced; and these changes have definitely improved the usefulness of the census statistics on families.

quasi-family groups totaled about 75,000, an aggregate of nearly 30,000,000 and an increase since January 1, 1920, of 23.1 per cent. This increase is considerably in excess of the reported rate of population growth (16.1 per cent) during this ten-year period—a circumstance which is explained by the very substantial decline in the size of the average family.

The American family has diminished steadily in size for several decades, the average population per family including institutions, etc., having dropped from 4.9 in 1890 to 4.1 in 1930.[2] The corresponding change in the average size of the private family has more real significance; but private families were counted separately only once prior to the recent census (viz., in 1900) and then on a slightly different basis. However, the indicated reduction in the average population per private family from 4.6 persons in 1900 to 4.0 persons in 1930 is accurate enough to be reasonably representative of the decline in the average size of such families. Decade by decade, changes in the size of the private family cannot be gauged exactly, but a clue to what may have been happening in the period between 1900 and 1930 can be gained from recorded changes in the average size of all families, including economic as well as private families.

POPULATION AND FAMILIES FOR THE UNITED STATES

	1930	1920	1910	1900
Population				
Total	122,775,046	105,710,620	91,972,266	75,994,575
In private families only	119,812,185	—	—	73,410,992
Families				
All families	29,979,841	24,351,676	20,255,555	16,187,715
Private families only	29,904,663	—	—	15,963,965
Population per Family				
All family groups	4.10	4.34	4.54	4.69
Per private family	4.01	—	—	4.60

[2] The average size of a family is usually expressed fractionally, as for example 4.35 persons per family, when what is really meant is that there are 435 persons per 100 families.

The considerable decline in the average size of family, as indicated in the accompanying table, may be divided into two parts: a decrease in the number of adults per family and a decrease in the number of children per family. The former factor declined from 2.61 to 2.51, or about 3.8 per cent, in the three decades, while the latter ratio dropped from 2.08 to 1.59, or 23.6 per cent. Expressed in different terms, only one-sixth of the total decline in the average size of family was due to factors affecting the number of adults per family, such as limited space in urban multi-family dwellings, the decrease in the number of domestic servants, and improved household facilities which have made it possible for old people to live by themselves; while five-sixths was due to the marked reduction in birth rates.

Many of the influences tending to lower the size of the family are more characteristic of urban than of rural areas. The average population per private family in cities having 25,000 or more inhabitants, 3.75 persons, was less than that in the rest of the country, 4.19 persons. The corresponding sizes of the quasi-families were 36.2 and 43.6 persons respectively, which seems to establish the fact that all families, whether private or economic, are smaller in the large urban centers than in the small cities and country districts. Consequently, the increased proportion of the population living in cities explains to a large extent the decline in the size of the family.

Regional differences, too, are important, as the rapidly growing regions—especially those receiving large influxes of migrants from other areas—have relatively small families, while those losing by interstate migrations have relatively large families. Thus the Pacific Coast region, the population of which includes many people who have retired from business, has the smallest average sized family, 3.4 persons, and the South Atlantic States the largest, 4.4 persons, a difference of an entire unit. In fact, the average family in the Southern States is much larger than that in other regions; while this is not notably

true in southern cities, it is strikingly so on southern farms. The families on the Pacific Coast are smaller both in urban communities and on farms than in other sections of the country.

For the first time, the 1930 Census gives data on the "kinship" family, which is a group related by blood, marriage or adoption and living in the same household. It differs from the private family by the elimination of lodgers, resident servants, guests, and foster children or wards. The most common size of kinship family was two persons, this group constituting 23.4 per cent of the whole number of such families, while three-person families formed 20.8 per cent of the total and four-person families 17.5 per cent.

The average size of kinship families was 3.81, but this average varied considerably between areas and racial groups. The urban family was about 18 per cent smaller than the farm family in 1930, the average sizes being 3.6 and 4.4, respectively, while the rural non-farm family average size was 3.7. As to variations by race, the average size of the native white family, 3.73, was smallest, followed by the Negro family with 3.81. The foreign-born white family was considerably larger than these two groups, with 4.08 average size, in spite of the fact that the great majority of these families were located in large urban centers. These variations in size between the racial groups reflect in part the differentials in their birth rates and in part the differences in their living standards.

Children in Families

In 1930 nearly 59 per cent of all families had no children under 10 years of age, while 39 per cent had no children under 21 years of age living at home. That is, 3 out of 5 homes were free from the confining cares of any young children (under 10), while 2 out of 5 families had no responsibilities for any children under 21 living at home. A considerable proportion of families, of course, consisted of elderly persons whose children had grown up and left the family, or were at least 10 years of age.

On the other hand, one-fifth of all families had one child under 21 years of age living at home and one-sixth had two children, while one-fourth of the families had three or more children each.

There are striking differences between urban and rural families with respect to the number of children. Nearly two-thirds of all urban families had no children under 10 years old living at home in 1930; and on the farms one-half of the families did not have any children in this age group. The percentage of one-child families was slightly larger in urban than in rural territory, but for all groups reporting two or more children under 10 years old the proportion in the farming areas was much higher than in the urban, and somewhat higher than in the non-farm rural. Moreover, only one in ten urban families had as many as four children under 21 living at home, contrasted with about one in four farm families. These differences, of course, reflect the higher birth rate in the country as compared with the cities.

Color and Nativity

In the census reports, families are classified according to the color and nativity of the head of the family. In a family recorded as foreign-born white, the head is a foreign-born person; the wife may be either native or foreign-born, but the children, since most of them have been born in this country, are practically all native white. Consequently, the proportion of the population which is native-white in any area is usually much larger than the proportion of native-white families. And, conversely, the percentage of the families classified as foreign-born white is likely to be much larger than the percentage of population classified as foreign-born white.

Native white families are the most important group, constituting 70.1 per cent of the total number in 1930, while the corresponding percentages for the foreign-born white and negro classes were 19.2 and 9.4, respectively. Three-fourths of the

native white families were of native parentage and accounted for over one-half of the total number of families. Since 1900 the proportion of native white families has increased markedly, while the relative importance of foreign-born white and negro families has declined appreciably. This development has tended to produce a more homogeneous market as regards nativity and racial characteristics, while the increased preponderance of native white families with their generally higher living standards has resulted in still further improving the sales prospects for utility services.

Economic Status of the Family

Certain economic characteristics of the population are revealed by the census classification of private families according to the number of gainful workers, the employment status of the homemaker, and the number of lodgers or boarders. Furthermore, some indication as to the extent of the top grade residence market is provided by the census returns showing the number of families having servants living in the home.

Gainful Workers

One of the chief factors affecting the household income is the number of employed persons per family. In the classification of families according to the number of gainful workers, all related members of the family who were reported as usually working at a gainful occupation were counted, including some who were temporarily unemployed at the date of the census. In general, it may be said that the number of gainful workers included those persons who were presumably contributing to the family income.

The census reports indicate that in 1930 five out of eight families had only one gainful worker, while one-fifth of all families had two members employed. On the other hand, 6 per cent of all families reported no gainful worker in 1930, representing mainly the families of widows and of elderly men

who had retired from active employment. Families with no gainful workers were most numerous in urban areas, but were proportionally highest in non-farm rural territory (10.4 per cent) and lowest on the farms (1.8 per cent). Moreover, they were relatively twice as numerous among families owning homes as in families renting homes.

Over 3,200,000 families, or 10.8 per cent of the total number in the United States in 1930, reported having three or more gainful workers. In this connection some allowance should be made in certain areas for the fact that many of the gainful workers were members of the family working without wages on the homestead. This was particularly true among the farm population of the South, where in several states one-fifth of all farm families had three or more members employed. While those persons were contributing to the family income, their status was not quite the same as that of persons working for outside employers for wages.

Homemaker by Employment Status

While the absence of children from the home releases the time of the mother from many homemaking duties and gives her freedom for social and recreational activities, it also offers the opportunity for outside employment, especially in the cities. The census reports include information as to whether the homemaker—designated as that woman member of the family who is responsible for the care of the home and family—pursued a gainful occupation in addition to her household duties. Nearly 4,000,000 homemakers, or one out of seven, were thus employed in 1930, and four-fifths of this number were employed away from home. Over one-half of those employed at home were engaged in agricultural occupations. The largest group of those employed on work away from home were in the service industries (30.4 per cent); the second largest group was classified as "industrial workers" (23.4 per cent); and the third largest as office workers (15.9 per cent). In view of the con-

centration of employment in activities which predominate in city life, it is not surprising to find that in the urban area in 1930 one in every six families had its homemaker employed for remuneration at other tasks than household duties at home.

Families Having Lodgers or Servants

The number of families having lodgers or servants may be significant as indicative of certain economic characteristics of the population. In 1930, nearly 5,000,000 lodgers or boarders were included in the households of about 3,000,000 private families, which in broad terms means that one in every ten families had one or more lodgers. In the classification of families according to the number of lodgers, certain other persons besides those directly reported as lodgers or boarders were included, among whom the most important group consisted of farm laborers living with the farm family. This involved a fine distinction between lodger and servant, the controlling consideration apparently depending upon whether or not the work was done outdoors or inside the home.

The proportion of families with lodgers was distinctly higher in urban than in rural areas, and was greater among tenant families than among owner families. As a class, tenant families probably are more likely to supplement their income by taking lodgers than are families who own their homes; and the best opportunities for renting rooms are in the cities where the largest proportion of unmarried workers is employed.

Certain information regarding the number of families having servants living in the home was obtained in the census as a by-product of the tabulation of families by number of lodgers. Only those families were included that reported no lodgers. On this basis slightly over 500,000 families had servants living in the home in 1930; two-thirds of this number were owner families, while 72 per cent were urban families. But because of the arbitrary definition of a farm laborer as a lodger, the published figures on servants in rural families are not directly comparable with urban data.

Dwellings

In telephone market studies the dwelling in which a family resides has been considered representative of its economic status, its standard of living and its purchasing habits. The latest census includes more information regarding the classification of dwellings by type of occupancy, the tenure and valuation of homes, and the proprietorship of homes by age of head of family than has previously been available. Probably one of the most important new features introduced is the classification of all non-farm homes according to the value of the home, if it was owned, or the monthly rent paid, if it was rented. These data permit a more accurate and comprehensive appraisal of the residence market than has hitherto been possible.

Classification of Dwellings by Occupancy

Household duties and the rearing of children are oftentimes much affected by the type of dwelling a family occupies, since wide differences in living conditions exist between single-family residences and multi-family dwellings. In 1930 all dwellings were classified for the first time into three groups, namely, those occupied by (1) one family only, (2) two families, and (3) three or more families. Apartment and tenement buildings form a large part of the last class, except in those areas where three-family houses are common.

Of the approximately 25,000,000 dwellings in the United States in 1930, slightly over 90 per cent were single-family residences, while 7 per cent were two-family houses and the remainder were of the multi-family type. One-family homes predominated in the rural areas, while double and multi-family dwellings were found principally in the cities. In fact, 3 out of every 8 families in the urban communities in 1930 lived in apartments or flats. Apartment dwelling is closely related to the increasing mobility of families, for few of such dwellings are owned by the families living in them.

Between 1900 and 1930 the excess of families over occupied dwellings increased by nearly 3,000,000, resulting in an increase in the ratio of families per dwelling from 1.12 at the close of the last century to 1.19 in 1930. This excess of families over dwellings is most pronounced in the northeastern section of the country, where the population is living largely under urban conditions with considerable concentration of families in multi-family dwellings. However, the increase of multi-family dwellings has as yet had little effect on average conditions throughout the country, for in 1930 76.4 per cent of all American families lived in one-family dwellings, and in the rural area the proportion amounted to 94.4 per cent.

Ownership and Valuation of Homes

Closely associated with the classification of dwellings by type of occupancy is the classification of homes by tenure, whether owned or rented. Slightly over one-half of all homes (about 51 per cent) were rented in 1930; in 1900 the situation was about the same.

While the total number of owned homes nearly doubled between 1900 and 1930, the owned farm homes actually declined numerically, a decrease of over 300,000 occurring during the past census decade, due to the many changes that have taken place in the agricultural situation in that period. During this period the owned non-farm homes tripled in number and increased from 35 per cent of the total homes in 1900 to 45 per cent in 1930.

More significant than the mere differentiation between owners and tenants as character indices of the residential market are the values of owned homes and the monthly rentals of rented homes. The values and rentals of non-farm homes have been assembled in 10 groups and this grading makes possible a classification of families according to economic status, or, perhaps more literally, according to purchasing power. In fact, the figures for home values and rentals provide a fairly

sound basis for comparisons of family incomes by cities or by regions. Whereas the value of the figures for determining the absolute level of incomes is slight, due to the shrinkage in realty values everywhere since the census was taken, their usefulness for indicating relative conditions remains almost undiminished.

NON-FARM HOMES BY VALUE AND MONTHLY RENTAL
FOR THE UNITED STATES: 1930

Owned Homes			Rented Homes		
Value	Number	Per Cent	Monthly Rental	Number	Per Cent
Value under $1,000	794,724	7.6	Rental under $10	1,563,952	12.7
$ 1,000 to 1,499	570,047	5.4	$10 to 14	1,330,927	10.8
1,500 to 1,999	531,277	5.1	15 to 19	1,302,387	10.5
2,000 to 2,999	1,167,325	11.1	20 to 29	2,545,208	20.6
3,000 to 4,999	2,343,769	22.3	30 to 49	3,191,435	25.8
5,000 to 7,499	2,297,029	21.9	50 to 74	1,503,401	12.2
7,500 to 9,999	989,468	9.4	75 to 99	343,071	2.8
10,000 to 14,999	906,557	8.6	100 to 149	163,292	1.3
15,000 to 19,999	339,535	3.2	150 to 199	46,297	0.4
20,000 and over	354,337	3.4	200 and over	45,750	0.4
Not reported	209,318	2.0	Not reported	315,829	2.5
Total	10,503,386	100.0	Total	12,351,549	100.0

In order to place owned homes on a comparable basis with rented homes and thus obtain the total number of families in any area that fall within the limits of a given income bracket, it is probably reasonable to apply the theory that one month's rent approximates 1 per cent. of the total value of a property. Thus, the owned homes valued from $5,000 to $7,500 could be combined with the homes having a monthly rental from $50 to $75 to obtain the total families in the income class represented by that rental group.

The median value of all owned non-farm homes in the United States in 1930 was $4,778, ranging from $7,500 in New York to under $1,000 in New Mexico; while the median monthly rental of all rented non-farm homes was $27.15, ranging from

$42.00 in New York to less than $10.00 in Alabama, Mississippi, and South Carolina. When broad geographical differences are considered, it is found that home values were generally higher in cities than in rural areas, and were lower in Southern States, both urban and rural, than in other parts of the country, with the exception of some of the Mountain States.

Tenure of Home by Age of Head of Family

As might be expected, the smallest proportion of owned homes in 1930 was reported for the proprietors in the youngest age group, with the proportion of owners increasing in each age group up to the highest. Conversely, the proportion of rented homes was largest among the youngest proprietors, and was lower in each succeeding age group. In view of the increasing proportion of home owners in successively older groups of heads of families, the apparent slight increase in home ownership between 1900 and 1930 may be fully explained by the higher average age of the population at the latter date.

Over one-half (54.6 per cent) of all men aged 65 years or more were reported as home owners in 1930. Even in urban territory, where tenancy in all age groups was most pronounced, 49 per cent of all men 65 years of age and over were classed as homeowners, while in the rural areas the proportion was materially higher, especially on the farms. But these percentages do not represent the complete economic story regarding home ownership in the upper ages. Many elderly men of independent means had their married children living with them and consequently did not appear as heads of families. This situation is well illustrated by conditions among the farm population. Over 500,000 farm tenants, or one-fifth of the total number in the United States in 1930, were closely related to their landlords. Presumably, many of these landlords were in the upper age groups and might not appear as heads of families or home owners because they lived with relatives or friends, or perhaps even in rented quarters. Under conditions where per-

haps as many as two-thirds of all men aged 65 years or more are property owners, the common conception of a high degree of dependency among old men may need to be modified.

Summary

In any appraisal of the residential market, it is possible to distinguish certain inherent differences in the composition of the principal population classes. Fundamental variations in family characteristics exist between nativity and racial groups, between owner and tenant families, between urban and rural classes and between the several regions of the country.

In the percentage distribution of families by age and nativity of the head of the family in 1930, the average age appeared considerably higher for the foreign-born white than for the native white class. This is largely explained by the fact that the heavy immigration of aliens occurred 16 to 29 years prior to the 1930 census. These considerable acquisitions of foreign-born in the past are reflected in the increasing number of native whites of foreign or mixed parentage, even though the foreign-born population declined numerically during the past census decade.

Because restricted immigration since 1914 has altered the normal age distribution of the foreign-born in relation to total population and, furthermore, because four-fifths of all foreign-born families live in urban areas, a direct comparison of the characteristics of native white with foreign-born white families on an over-all basis is not significant. However, considering urban territory only, it is significant that the percentage of home ownership in every age group is uniformly higher for native white heads of families than for the foreign-born white. Another significant difference in family characteristics between nativity classes is shown in the data relating to the occupations of the gainfully employed homemakers. The great bulk of the homemakers employed away from home who were reported as professional and office workers and as saleswomen were na-

tive whites, while the foreign-born white homemakers were employed principally as industrial workers and as servants.

There is no doubt that, from the economic standpoint, the colored races constitute the poorest section of the market when compared with the other classes, especially the native white. This is reflected in the comparatively low degree of home ownership (25 per cent) among the colored races, in the low median value of owned non-farm homes and the low median rental of rented non-farm homes, in the relatively greater proportion of families having lodgers and in the much higher percentage of families with homemakers gainfully employed, principally as servants away from home and as agricultural workers on the home farm.

In general, private families are smaller in urban than in rural areas, especially in the farm areas, due principally to fewer children. This may be associated with the fact that single family residences predominate in the rural districts, while duplex and multi-family dwellings are chiefly characteristic of city life. In this connection, it should be noted that the median values and rentals of non-farm homes were distinctly higher in urban than in rural territory in 1930.

Additional indexes of general market characteristics show that the proportion of families with lodgers and of families having their homemaker gainfully employed was distinctly higher in urban than in rural areas, and was greater among renters than among homeowners. Also, as might be expected, families with servants were relatively more numerous in the cities than in the country, and also more numerous among homeowners than among tenants.

The general basic differences in the characteristics of American families described above are important factors when studying the potential market for residence telephone service; and they should be carefully considered when attempting to appraise the sales possibilities in any community or region.

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